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NOTES ON THE GENUS *EULEIA* WALKER IN NORTH AMERICA (Diptera: Tephritidae)

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There are two European species of *Euleia* Walker, one of which, *heraclei* (L.), is widely known as the celery fly. One of the two North American species, *fratria* (Lw.), is called the parsnip leaf miner and is of some economic importance in the United States. The purpose of the present paper is to discuss the nomenclatural status of *Euleia* and to review the two North American species, *fratria* (Lw.) and *uncinata* (Coq.), belonging to it.

Genus *Euleia* Walker

Euleia Walker, 1836, Ent. Mag. 3 (art. 5):81 [1 species (*Musca onopordinis* F.)=*Euleia heraclei* (L.)].
Philophylla Rondani, 1870 (p.p.), Bul. Soc. Ent. Ital. 3:175.
Acidia (in part) of authors.

All hairs shining black; head, thorax, abdomen, and legs yellow to black, Three pairs lower fronto-orbitals; two pairs upper fronto-orbitals, the posterior pair reclinate but never convergent; face slightly receding and not at all produced forward at oral margin; frons with very fine, short, black hairs; postoculars slender and sharply pointed. Presuturals present; dorsocentrals in a line, or very slightly behind a line, drawn between the anterior supra-alars; two pairs scutellars; metathorax with paired dark areas. Wing as shown in figs. 8 and 9, always with a large light area in distal third of cell 1st M_2 and a light spot in middle of cell R; vein R_{4+5} haired to beyond vein r-m; vein r-m distinctly beyond the center of cell 1st M_2. Ovipositor sheath (fig. 7) shorter than preceding abdominal tergite; ovipositor as in fig. 7; male clasper terminating in two distinct projections (figs. 1 and 2) at an angle to each other.

Walker, in 1836, proposed the genus *Euleia,* with *Musca onopordinis* F. as sole species and with *Musca caesio* Harris and *Musca centaureae* F. in synonymy. Under the present rules it is necessary to consider *Euleia* as originally monobasic, with *onopordinis* as the sole included species. The names originally in synonymy with it may not be used for the designation of a type for *Euleia.* Both *onopordinis* and *centaureae* have long been accepted as synonyms of *Musca heraclei* L., but *caesio* has been shown to be specifically and generically distinct.

In 1870 Rondani established the name *Philophylla,* with *Musca caesio* Harris as type and in 1871 listed *onopordinis* and *centaureae* as two Italian species belonging in it. Hendel (1927) regarded the name *Euleia* as preoccupied[1] and used *Philophylla* Rondani (1871) as the generic name for

[1] I can find only the previous name *Eulia* Huebner (Lepidoptera).

heraclei, under the impression, according to Benjamin (1934), that Rondani's 1871 paper represented a change in concept of the genus. Therefore *Philophylla* in the sense of Rondani (1871) becomes synonymic in part with *Euleia* as discussed in the present paper.

Coquillett (1910), apparently assuming that all names listed by Walker were available for the purpose, chose *caesio* as the type of *Euleia.* If this were allowable, *Euleia* would become a synonym of *Acidia* R.-D., since the European *heraclei* L. bears a great deal of resemblance to *Acidia cognata* (=*Tephritis cognata* Wied., 1817), which is the type of *Acidia* by designation of Rondani (1870). For a number of years the two species were considered by European authors to be congeneric, and since the North American *fratria* Loew so closely resembles *heraclei,* most American authors have followed Loew (1873) in assigning *fratria* to *Acidia.*

The species of *Euleia* are closely related to those of *Euribia,* from which they are easily distinguished by the presence of the large light spot in the distal third of cell 1st M_2 and the smaller one in the center of cell R, and by the more distal position of vein r-m, which in *Euleia* is situated so that its distance from vein M along vein M_{1+2} is always shorter than vein M. The North American genus *Epochra* is also closely related but lacks presuturals and has a different wing pattern. *Epochra, Euribia,* and *Euleia* belong to the tribe Trypetini of the subfamily Trypetinae and all bear at least superficial resemblance, expect for wing-pattern details, to the yellow-bodied species of *Rhagoletis.*

Key to the North American Species of *Euleia* Walker

Wing with an uninterrupted hyaline area in cells R_3, R_5, and 2nd M_2, the dark band immediately posterior to it complete; cheek not more than one-fifth the eye height in profile ..... *fratria* (Loew)

Wing with this hyaline area closed at posterior margin, the dark band immediately posterior to it incomplete; cheek at least one-fourth the eye height in profile ..... *uncinata* (Coquillett)

Euleia fratria (Loew), n. comb.
(Figs. 1, 2, 5, 7, 8)

Trypeta fratria Loew, 1862, Smiths. Misc. Coll. 6(1):67, pl. II, fig. 4 [holotype ♀, type loc., "United States"]; Loew, 1873, *ibid.,* 11(256): 234, pl. X, fig. 4 [descr. ♀]; Coquillett, 1895, Insect Life 7:383; Curran, 1934, Fam. Gen. North American Dipt. p. 287; fig. 20.

Trypeta liogaster Thomson, 1868, Eugenies Resa 6(2):578 [holotype ♀, type loc., California].

Acidia fratria, Loew, 1873, Smiths. Misc. Coll. 11(256):225, 329, 337 [generic transfer]; Doane, 1899, Jour. New York Ent. Soc. 7:178 [notes, distrib.]; Johnson, 1900, *in* Smith, 27th Ann. Rept. State Bd. Agric. New Jersey, Suppl. p. 687 [distrib.]; Aldrich, 1905, Smiths. Misc. Coll. 46 (1444):603 [distrib.]; Chittenden, 1909, U. S. Dept. Agric. Bur. Ent. Bull. 82(2):9-13 [history, distrib., biology]; Johnson, 1910, Ann. Rept. New Jersey State Mus., 1909:801 [distrib.]; Phillips, 1923, Jour. New York Ent. Soc. 31:129, pl. 18, fig. 11 [in key, distrib.]; Johnson, 1925,

Proc. Boston Soc. Nat. Hist. 38:97 [distrib.]; Johnson, 1925, Occas. Papers Boston Soc. Nat. Hist. 7:261 [distrib.].

Trypeta (Acidia) fratria, Osten Sacken, 1878, Smiths. Misc. Coll. 16(270): 189 [distrib.].

Acidia heraclei L. (misdet.), Frost, 1924, Cornell Univ. Agric. Exp. Sta. Mem. 78:32 [hosts, biology, distrib.]; Needham, *et al.,* 1946, Leaf-mining Insects, p. 245 [life history, damage].

Philophylla fratria, Hendel, 1927, Flieg. Palaearkt. Reg. 49:99.

Previously recorded distribution.—United States: Washington (Almota, Pullman); California; Missouri (Cadet); New Hampshire; Vermont; Massachusetts; Connecticut; New Jersey; New York; District of Columbia. *Canada:* Ontario (Toronto); Quebec (Montreal).

Material examined in present study. Unless otherwise noted, all material is in the U. S. National Museum. Symbols employed are as follows: CM= Carnegie Museum, Pittsburgh; MCZ=Museum of Comparative Zoology, Harvard University; PPC=Plant Pest Control Division, Agricultural Research Service, U. S. Department of Agriculture.

Type, ♀, of *fratria* Lw. in the Museum of Comparative Zoology, Harvard University, with the following labels: "United States, Schaum," "Loew Coll.," "fratria Lw.," and "Type 13292." Type, ♀, of *liogaster* Thomson,

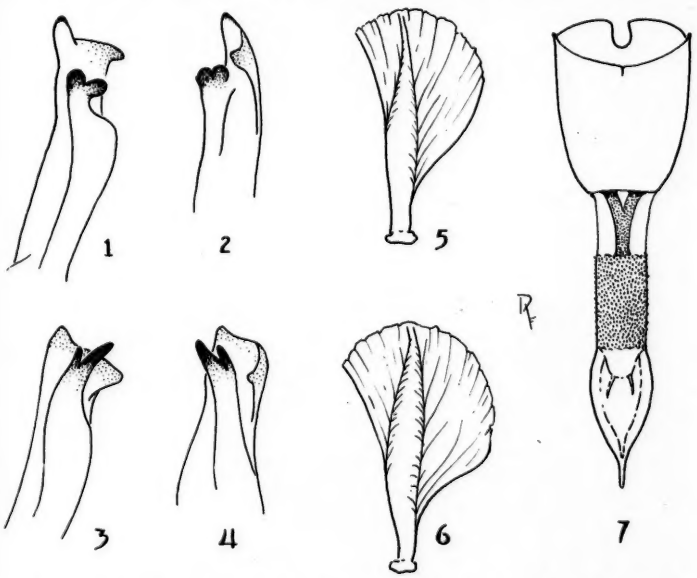

Fig. 1. Left clasper of *Euleia fratria* (Lw.), ♂, inner surface. Fig. 2. Same, anterior surface. Fig. 3. Left clasper of *Euribia fractura* (Coq.), ♂, inner surface. Fig. 4. Same, anterior surface. Fig. 5. Apodeme of *E. fratria* (Lw.), ♂. Fig. 6. Same, *E. uncinata* (Coq.). Fig. 7. Ovipositor and ovipositor sheath, ♀, *E. fratria* (Lw.).

in the Naturhistorische Museum, Vienna, with the following labels: "California," "Kinb.," "Typus," "401/57" [in red], and "Trypeta liogaster Thom." WASHINGTON: 3 ♂, 2 ♀; Almota, Vancouver; 25.VI-21.X. MONTANA: 1 ♂; Glacier Park Sta.; VII.1924. WYOMING: 1 ♀; Yellowstone Nat'l Pk.; 2.VII.40 (CM). CALIFORNIA: 1 ♂; Albany, 29.IV.1958. ILLINOIS: 1 ♂, 1 ♀; Algonquin, Urbana; 18.VI.03. OHIO: 1 ♀; Girard; VI.1925. MASSACHUSETTS: 1 ♂, 1 ♀; Cambridge; V.1921 (MCZ). NEW JERSEY: 2 ♀; Enola, Riverton; V.1906 & 1927. PENNSYLVANIA: 7 ♂, 15 ♀; Allegheny Co., Castle Rock, Highspire, Overbrook, Philadelphia, Pittsburgh, Roxborough; 15.V-14.VII (CM & USNM). MARYLAND: 1 ♂, 1 ♀; Hyattsville; 9.V.17. DISTRICT OF COLUMBIA: 30 ♂, 9 ♀; 8.II-IX. VIRGINIA: 2 ♀; Rosslyn; 1-8.V.1913. FLORIDA: 3 ♀; Daytona, Jacksonville; 18.II-24.V (MCZ, PPC, USNM).

Discussion.—The wing pattern (fig. 8), together with the characters set forth in the generic description, distinguish *fratria* from all other North

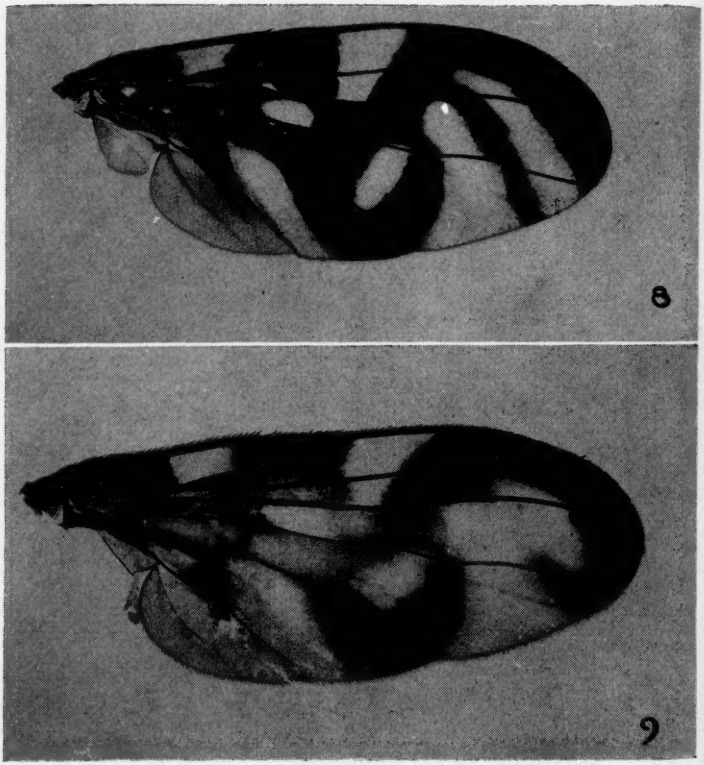

Fig. 8. Left wing, dorsal surface, ♀, *E. fratria* (Lw.). Fig. 9. Same, *E. uncinata* (Coq.).

American tephritids. The characters by which it differs from *uncinata* (Coq.) will be found in the discussion of that species.

The resemblance of *Euleia heraclei* (L.) to *fratria* is striking. It is commonly assumed that these two species are distinct in spite of the characters they share, and I prefer to consider them so until interbreeding is demonstrated to occur between live populations of the two. Hendel (1927) indicates that *fratria* has a wider and shorter frons, shorter and wider wings, and a much less convex face than *heraclei*. Rough measurements of material in the U. S. National Museum confirm these differences.

It is of interest to note that *heraclei* has a much wider recorded host range than *fratria*, having been noted from a total of 16 plants, which include parsnip *(Pastinaca sativa)* as well as species of *Rubus* and others somewhat removed from the Umbelliferae. *E. fratria* has been recorded many times in *Pastinaca sativa*, its most common host plant, and it has been reared by Frost (1924) from *Heracleum lanatum* and *Cryptotaenia canadensis*, both members of the same subfamily of Umbelliferae, and from *Prenanthes canadense*, a composite. As far as is known, these are the only hosts of *fratria*. Several specimens in the National collection from Washington, D. C., bear the label "Aug. 1903, leaf miner in parsley." I assume this to be an error for parsnip, since the shape of the leaf of parsley does not seem able to support a blotch leaf mine large enough for *fratria*, nor has parsley ever been recorded as a host for this fly. Chittenden (1909) has described and figured the type of damage caused by *Euleia fratria* (Lw.).

Hendel (1927) has summarized the available European literature on color forms of *heraclei*. There are two types—one with a shiny black body, and one with the thorax and abdomen of various shades of light brown to yellow. The former is called "form *centaureae*"; it differs not at all from the yellow form, *"heraclei,"* except in degree of pigmentation. It was thought by early observers that the dark form represented a winter generation, but various attempts at seasonal correlations constantly tend to disprove this hypothesis. It should be noted that only a light brown to yellow form of *fratria* is known to exist in North America. None of the specimens in the National collection are blackish, and most wings are lighter in color than that shown in fig. 8 from Vancouver, Washington. Furthermore, no geographical or altitudinal correlation with color appears to exist.

Euleia uncinata (Coq.), n. comb.
(Figs. 6, 9)

Acidia uncinata Coquillett, 1899, Jour. New York Ent. Soc. 7:260 [holotype ♀; type loc. Ft. Wrangle, Alaska]; Aldrich, 1905, Smiths. Misc. Coll. 46 (1444):603 [distrib.]; Cole, 1921, Proc. Calif. Acad. Sci., 4th Ser. 11 (14):175; fig. 3 [descr. ♂, distrib.].

Previously recorded distribution.—Alaska (Ft. Wrangle); Pribiloff Islands (St. Paul Island).

Material examined in this study.—ALASKA: 1 ♀; Golovin (Reindeer Camp); 19.VII.1930; E. C. Cushing. PRIBILOFF ISLANDS: 1 ♂, 1 ♀; St. Paul Island; 1 ♀, VII, 1923; 1 ♂, 23.V.1914.

Discussion.—Several characters will clearly distinguish *uncinata* from *fratria*. In profile the face of the former is less convex, and the third antennal

segment is somewhat more obtusely rounded. The eye of *uncinata* is narrower, and the cheek is nearly one-fourth the eye height as compared to one-fifth to one-sixth in *fratria*. The differences in the wing patterns of the two species (figs. 8 and 9) are most striking, especially on the outer third of the wing disc. In all specimens of *fratria* seen in this study, the diagonal hyaline area in cells R_3, R_5 and 2nd M_2 is never closed at the wing margin, and the posteriorly adjacent dark band is always complete. The outer third of vein M_{1+2} in *uncinata* contains a rather distinct bend which causes the terminal portion of that vein to be at a larger angle to vein R_5 than in *fratria*. I can find no measurable characters in either the male genitalia or the ovipositor and ovipositor sheath to differentiate the two species, although the variable apodeme shows a slight difference (figs. 5 and 6).

Nothing is known about the hosts or habits of *uncinata*. It is restricted in distribution and has never been reported as an economically important insect.

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A New Entomological Journal

Volume 1, number 1 of "Pacific Insects," dated July 15, 1959, has been received. It is a large (172 pages), excellently printed journal, and should be a welcome and distinguished addition to the list of entomological periodicals. Four issues annually, totaling about 400 pages, are planned.

An explanatory paragraph states, "This journal is the organ of the program 'Zoogeography and evolution of Pacific insects' sponsored by the Entomology Department, Bishop Museum, Honolulu. It is devoted primarily to monographs or zoogeographical papers on insects and other terrestrial arthropods from the Pacific area, including eastern Asia, Australia, and Antarctica." Dr. J. Linsley Gressitt of the Bishop Museum is editor.

The subscription rate is $5.00 per volume, payable to the business manager of the journal, Dr. C. M. Yoshimoto, Bishop Museum, Honolulu. Remittances in Yen or Sterling may be made to the business agent in Japan, Dr. K. Yasumatsu, Kyushu University, Fukuoka, Japan. C.D.M.

A MICRO SYRINGE FOR LABORATORY GRAIN FUMIGATION[1]

JOHN R. PEDERSEN[2]
Kansas State University, Manhattan

An improved apparatus is being used in this laboratory to provide more nearly accurate measurement of very small increments of fumigant and to deliver the fumigant rapidly into test chambers. Various attempts to solve this problem included use of (1) a 1 cc. tuberculin syringe with 0.01 ml. graduations; (2) micropipettes of various sizes; (3) fumigant dilution with acetone; and (4) a Micro Syringe-Burette, reported here, with 0.25 ml. capacity and 0.0001 ml. graduations (Fig. 1.). Only the Micro Syringe-Burette fulfilled the requirements. It is a precision instrument sold by Scientific Glass Apparatus Company, Inc., Bloomfield, N.J.; The California Laboratory Equipment Company, Berkeley, Calif., and perhaps others.

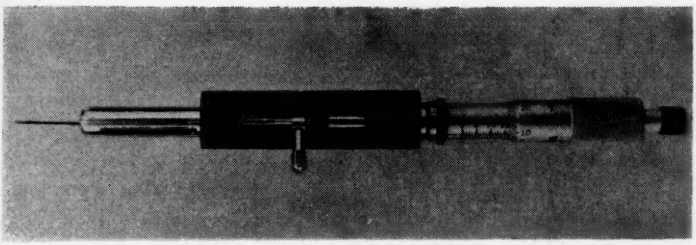

Fig. 1 Micro Syringe-Burette (syringe configuration). Total capacity 0.25 ml. graduated in units of 0.0001 ml.

The syringe chamber is a precision bore tube of "Pyrex" brand glass fitted with a Teflon[3] plunger attached to a stainless steel shaft. The delivery end of the syringe is fitted with a ¾-inch modified 27-gauge, dental-type hypodermic needle of stainless steel. The needle may be removed and replaced with a burette of "Pyrex" brand glass for the burette configuration. A micrometer control, graduated in units of 0.0001 ml., allows measurement of extremely small increments of fumigant. The syringe is versatile in that it may be discharged either with the micrometer control or by a plunger type action. The syringe configuration using the plunger type discharge was found better suited for our fumigation tests.

The syringe also is easily adapted for other laboratory work. By using a 1½-inch needle, the syringe is easily modified for injecting liquid samples into a Beckman GC-2 gas chromatograph. The syringe configuration may also be used for topical or oral application of insecticides to individual insects. In the burette configuration it functions as a micropipette.

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[1] Contribution No. 714, Department of Entomology, Kansas Agricultural Experiment Station, Manhattan.

[2] Instructor.

[3] Trademark for Du Pont Tetrafluoroethylene.

Although data are not included here, the Micro Syringe has proved reliable in providing more nearly accurate reproduction of dosage-mortality data, particularly advantageous when working with small-sized fumatoria. Measurement of extremely small increments and rapid delivery of the fumigant make it possible to conduct tests in chambers of 1-gallon capacity. When grain commodities are used in fumigation tests, the total quantity of commodity required may be appreciably reduced by use of small size chambers.

ERRATUM

In Jour. Kansas Ent. Soc., 31(3):227, July, 1958, the date of collection for the primary types of *Evidomyia infida* Reinhard should read V-1-56, M. Wasbauer. H. J. Reinhard

NOTES ON OVIPOSITION BEHAVIOR RESPONSES OF THE CODLING MOTH, *CARPOCAPSA POMENELLA* L., TO AIR MOVEMENT, TEMPERATURE, AND LIGHT[1]

RALPH L. PARKER
Emeritus Professor of Entomology

These notes bring together and supplement information partially hidden in some of the biennial reports of the director of the Kansas Agricultural Experiment Station which contain only briefly summarized Station project results. The names of the research workers are not listed in all cases. Dr. Paul M. Gilmer, formerly of the Bureau of Entomology & Plant Quarantine, U.S.D.A., was one of the leaders of Purnell Project 163, Codling Moth Investigations, from 1927-1932 and made many field observations, principally in the Wichita area.

RESPONSE TO AIR MOVEMENT

The 1928 report states that observations were made during the early spring of 1927 on the oviposition behavior of the codling moth. At that time a large air-conditioning apparatus in the greenhouse insectary was used to rear the moths. The air movement was approximately 4 miles per hour. It was found that the females would not oviposit unless the ventilating fan was stopped. That was disclosed when an electrical failure occurred during

[1] Contribution No. 738, Department of Entomology, Kansas Agricultural Experiment Station, Manhattan.

trials to determine the effect of temperature on the development of the moth. Several trials following this first interruption of air movement were made from before sundown until 9 p.m. with the same results. In other words, even a low rate of air movement in the cages within the air-conditioning machine was sufficient to prevent oviposition with other conditions favoring it. When there was no perceptible air movement, the moths readily oviposited just after sundown or at times of very low light intensity and favorable temperature. In southern Kansas, heavy egg deposition would take place on the leeward side of trees but not on the windward side when (1) the temperature was 65°F. or above, up to certain high temperatures, and (2) when there were early evening and morning breezes of a very low velocity generally from one prevailing direction. Apparently the trees reduced air movement to below the critical velocity.

Borden (1931) stated "The flight of the moth is undoubtedly greatly governed by several ecological factors including light intensity, humidity, temperature and air movement," and "One of the most notable factors in the field in controlling the flight is the starting of a breeze or wind. Just the faintest air movement over tree tops effectively cuts down the flight. Evenings when a wind was blowing, very few, if any, moths were observed even though the temperature and light intensities were still favorable. The few moths that arose on these evenings kept very close to the trees and were comparatively inactive."

RESPONSE TO TEMPERATURE AND LIGHT

As noted above, oviposition behavior is not dependent solely on one factor but upon a combination of several factors favorable at a specific time. Temperatures within the air-conditioning machine were maintained continuously at various stated levels in trials between 60° and 70°F. No eggs were laid where the temperature was below 65°F. "Egg-laying in the spring is heavy when the critical low temperature in the early evening is 65 degrees F. and the air quiet. After May 25, in the Wichita, Kansas, area, the temperature every night usually is 65 degrees F., or higher, which gives conditions favorable for egg-laying during the remainder of the season." (Call, 1928, p. 79.)

"Light may have some influence on the activities of the adult, but temperature is the stronger of the factors. During periods of extremely high temperatures (critical high temperature 88° to 90°F.) in the summer, the moths will not lay eggs until there is a change in the temperature from the coolest point toward warmer. This reaction usually takes place between 6 and 7 a.m." (Call, 1932, p. 98.) Isely (1939) summarized that "The most favorable mean temperature for high daily oviposition appears to be 27°C. (80.6°F.). . . . Mean temperatures of 30°C. (86.0°F.) or above reduce the daily average number of eggs deposited by moths that continue reproducing and abruptly terminate the oviposition period of others."

Orchard topography produces night temperature differences which may cause false conclusions to be drawn when the orchard temperature is within a degree or two of the critical low temperature for egg-laying. Low area temperatures are generally lower than those at the top of hills and thus

at times egg-laying will take place in trees near or at the top of land crests; whereas there will be none at the lowest levels.

Isely and Ackerman (1923) summarized as follows: "At least partial darkness is necessary for heavy oviposition, and oviposition begins at a temperature above 62°F."

Slingerland (1898) and Spuler (1927) stated that codling moth adults are not attracted to lights. Experiments with strong lighting in orchards during the night have been used as a deterent to egg-laying to prevent infestation of apples. It is generally known that the moth flies only during periods of low light intensity. Borden (1931) stated, "The variance in the tree area is due to the effect of shadow or slanting rays of light in the higher tops." During 1927, while using the air-conditioning machine, it was found that at the time the 4-mile per hour air movement was stopped the electric light had to be turned off to obtain egg-laying.

Gilmer conducted an investigation of sectionally-divided individual trees. He divided these trees by imaginary parts into 12 approximately equal sections, each one centering north, east, south, and west, and running from top to bottom. Each section was further subdivided to top, middle, and bottom, horizontally. At harvest time the fruit from each division was graded separately for larval injury. He found that the south and east sections of the trees generally had more worms, showing the effect of the sun's heat. Vertically, the top, middle, and bottom portions usually showed worminess in unsprayed plots to be approximately equal, unless the orchard was quite dense with overlapping branches that prevented light penetration. In every section the fruit from the interior of the tree was almost invariably wormier than that exposed on the outside of the tree because of light and air movement. Excluding the factors of temperature, air movement, and light, the codling moth showed no preference for any portion of the tree, either vertically or horizontally.

These oviposition behavior responses are considered important in determining periods of egg-laying and, more important, in determining spraying times to control the codling moth.

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A MORPHOMETRIC ANALYSIS OF STRAINS OF *DROSOPHILA MELANOGASTER* DIFFERING IN DDT-RESISTANCE[1,2]

ROBERT R. SOKAL
The University of Kansas, Lawrence, Kansas

INTRODUCTION

This paper is one of a series reporting the findings of a research project on the genetics and ethology of DDT-resistance in *Drosophila* and houseflies conducted at the Department of Entomology of the University of Kansas. The research reported here includes measurements of 14 morphological characters from 14 different strains of *Drosophila melanogaster* Meigen. The possible correlation of these measurements with the DDT-resistance status of the flies is investigated. Other pertinent points regarding these measurements are discussed.

The present study parallels an earlier one investigating possible morphological differences correlated with DDT-resistance in nine strains of the housefly *Musca domestica* L. (Sokal and Hunter, 1955). It was the conclusion of that paper that while strain differences could be demonstrated for a variety of characters and ratios, these differences were not correlated with resistance and that, furthermore, the relative position of strain means changed from generation to generation without apparent pattern. Variation among the rearing vessels was found responsible in part for the added variance of strain means of different generations, but the percentage of the variance thus accounted for could not completely explain the fluctuations actually observed.

These findings contradicted the conclusions of Bigelow and LeRoux (1954) who in the housefly found the ratio of the width of the second abdominal sternite to its length correlated with resistance.

Recent work has been unable to resolve this problem unequivocally. Morrison (1957) in a new study concludes that differences in Bigelow and LeRoux's ratio (X_5) are related to resistance, but a reanalysis of his data by Sokal and Hiroyoshi (1959) shows that this is true only for his male flies but cannot be proven in his females. These latter authors re-measured eight strains for both sexes and came to the overall conclusion that level of resistance cannot be related to magnitude of the X_5 ratio.

Bochnig (1956) appears to be the only one who has investigated the problem in *Drosophila*. Measuring seven morphological characteristics of five strains of *D. melanogaster* she showed that, in general, resistant strains

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were larger. The percentage increase of the resistant strains over the control strains from which they were derived differed considerably depending on the character studied. She concluded that morphological characteristics were not a very reliable indicator of resistance status, since the "Park" strain, which was originally more resistant than the "Berlin Wild" strain was smaller than the latter strain. It should be pointed out that Bochnig's flies were resistant as adults to DDT externally applied, while the resistance discussed in this paper is that of larvae to DDT in the medium.

Reasons were detailed in an earlier paper (Sokal and Hunter, 1955) why morphological correlates of DDT-resistance in houseflies are unlikely. These arguments need not be repeated here and, as will be seen in the discussion, they are even more pertinent for the *Drosophila* strains studied here. On the other hand it is important to investigate whether such correlation does occur, since in the unexpected event that it did, certain conclusions might be drawn regarding the uniformity or heterogeneity of the mechanism of DDT-resistance in the various strains tested.

MATERIALS AND METOHDS

The measurements were carried out as two series. In series I, undertaken in the spring of 1954, 14 morphological characters were measured on the following nine strains: 1.) The peripherally pupating strain (PP) and 2.) the centrally pupating strain (CP), which are lines selected for difference in site of pupation (Sokal, 1959); generation 22 was measured. 3.) A line of *Drosophila* selected for susceptibility of larvae to DDT in the medium (SS), 4.) a non-selected control line (NS), and 5.) a line (RS) selected for larval resistance to DDT-medium (Sokal and Hunter, 1954), measured in generation 38. 6.) The BS Canton (BS) line, derived from the original Canton-S strain of *Drosophila* maintained at the California Institute of Technology which had been sib mated for more than 20 generations and subsequently mass cultured. Strains selected for 7.) long larval period (LL), 8.) short larval period (SL) and 9.) a control line for these strains (CS), measured in generation 30. The latter three strains were developed by Hunter (1959). Detailed descriptions of how these strains were selected and methods of culture can be obtained in the papers cited.

Series II was measured in the summer of 1956 and the same strains were measured in the following generations: PP, CP, generations 65; BS (generation not recorded); NS, RS, SS generation 81; LL, SL, and CS generation 70. In addition five further strains were measured, which had been obtained from other laboratories, where they had proven to be resistant. SyS-102 (generation 71) and SySM-1 (generation 45) had been selected by Dr. J. C. King (1954, 1955); strains C_1, C_2 and K_x (generation not stated) were obtained from the laboratory of Prof. J. F. Crow of the University of Wisconsin.

In series I the parent generation was prepared by setting up 25 oviposition bottles per strain, containing a pair of parents each, and transferring ten eggs from each bottle to a vial of standard cornmeal-agar-molasses medium, as used in our laboratory. See Sokal *et al* (1959) for details of medium preparation. The offspring of these parents were collected two days after each emergence, pooled and preserved in 70% alcohol. A

sample of 33 flies of each sex was taken at random for each strain and measured. Varying numbers of female parents were preserved and also measured in order to permit comparisons between them and their offspring.

In series II fifty pairs in separate oviposition bottles were used per strain. Eggs from these bottles were distributed into a number of vials in such a way that genetic effects of parentage were confounded with environmental effects of vials. Fifteen eggs were reared per vial to insure optimum development. Flies were preserved in 70% alcohol after they had produced a sufficient number of eggs and the offspring were treated likewise after they had been permitted to mature for a period of two days past emergence. Thirty-five females were measured for each strain and for both generations.

Assays for larval resistance were performed by adding known amounts of p,p-DDT, dissolved in carbon tetrachloride, to liquid larval medium to produce varying concentrations of DDT ranging from 3.4 to 9.8 p.p.m. The carbon tetrachloride evaporated from the medium and left no demonstrable toxic residue in control experiments. In these assays the flies were reared, 10 per vial, in 6 dram shell vials (23x85 millimeters) filled to a height of 15 millimeters with larval medium. Approximately 20 such vials were used for each DDT dose. The total mortality (including larval, pupal and adult mortalities) was recorded for each vial. This method of DDT assay was standard procedure in our laboratory.

It was unfortunately impossible to obtain resistance assays for the strains at the very generations at which the measurements were made. However, numerous assays are available for most of these strains for a considerable number of generations prior to the time of assay. Eye-fit LD_{50} estimates were obtained for all assays, but when these data were subjected to a maximum likelihood probit analysis on a digital computer (see Sokal, 1958), a good many of them were shown to be so heterogeneous that no probit regression line could be fitted to the data. The author presumes that this would be a general tendency of most probit regression lines, which find their way into the literature without having been subjected to maximum likelihood analysis. He has cautioned previously against the ready acceptance of eye-fit lines as representing the actual resistance status of the organisms tested (Sokal, 1958a). Thus, after the maximum likelihood estimates had been computed, considerably fewer significant LD_{50} estimates were left than had been available before. The average LD_{50}'s indicated in Table 1 are based on various of these LD_{50} estimates. To list in detail the specific generations on which these estimates are based would unnecessarily lengthen the paper. The following summary should suffice: LD_{50}'s for series I in the CP-PP strains are based on all significant LD_{50}'s between generations 14 and 32; in the NS, SS, and RS strains from generations 21 to 42; in the larval period strains (LL,SL,CS) an overall average was taken presented by Hunter (1956). This average was also used for the LD_{50}'s of series II. In that series PP and CP estimates were based upon averages between generations 61 and 64 and those for the NS, SS and RS strains on the generations 43 to 81. The various strains obtained from other laboratories were assayed by us just once and are based on maximum likelihood estimates of a single generation, preceding the measurements by one genera-

tion. No resistance assays were available for the BS line and the SySM-1 line. It was assumed that the BS line was of the order of resistance of the non-selected control line (NS) and that the SySM-1 line was as resistant as the RS line which had been selected in a similar manner.

Flies to be measured were reared in medium to which was added sufficient dead brewer's yeast but no special live yeast except that transferred with the eggs. The flies were reared in a temperature chamber at $25 \pm 1°C$. Bilaterally symmetrical structures were measured at random from the left and right side of the fly. The following characters were measured in series I:

A. Length of the wing from the distal end of wing vein R_{4+5} to the humeral cross vein. This is slightly longer than the wing length criterion adopted by Bochnig (1956).
B. Width of wing from the tip of vein R_{2+3} to the tip of vein M_{3+4}. This is the identical width measurement employed by Bochnig (1956).
C. Length of metafemur.
D. Length of the metatibia.
E. Length of the first metatarsal segment.
F. Length of the fourth metatarsal segment.
G. Length of the third antennal segment.
J. Number of dorsal setae on the arista of the antenna.*
K. Number of ventral setae on the arista of the antenna.*
L. Length of the scutum along the midline.
M. Length of the scutellum along the midline.
N. Distance between the inner margins of the eyes, measured across the anterior ocellus.
O. Number of setae on the fourth abdominal sternite.
P. Number of setae on the fifth abdominal sternite.

Characters O and P differ from those of the housefly study (Sokal and Hunter, 1955), since in the housefly the third and fourth abdominal sternites were used. In *Drosophila,* however, the third sternite was difficult to examine and we therefore moved our study of the setae of the sternites posterior by one segment. Characters A and B were studied with a binocular microscope; C, D, E and F were measured with a compound microscope; all other characters were studied with a Leitz Ultrapak microscope. Errors of measurement were all below 5% of magnitude except for characters O and P. Some of the statistical work was performed by IBM punch card machines.

In series II it was decided to restrict the measurements to fewer variables. This was done by means of a factor analysis which was to identify the major sources of variation among the pooled data of the offspring of series I. The method was identical to that used in the earlier paper by Sokal and Hunter (1955) and it is therefore not necessary to repeat an account of it here. Table 2 gives the results of the factor analysis similar to Table 3 in the paper by Sokal and Hunter. On the basis of this table, character A was chosen to represent general size as well as a wing factor; character D was chosen to represent a hind leg factor; characters F and G appeared to

* Transformed into square roots of actual counts for statistical analysis.

be independent dimensions largely unaffected by general size and were therefore chosen. Character J is entirely unaffected by general size, as is character K. Although these two bristle numbers of the antennal arista were not related with each other, as they had been in the housefly data, only one of these (J) was used in order to save measuring time. Character O was chosen to represent an abdominal setae factor.

TABLE 1. Resistance of *Drosophila* Strains Measured in This Study.

Strain	LD_{50} in p.p.m. DDT		Strain	LD_{50} in p.p.m. DDT	
	Series I	Series II		Series I	Series II
PP	4.8	4.0	SL	5.0	5.0
CP	3.7	3.2	CS	6.6	6.6
BS	like NS	like NS	SyS-102	....	18.7
NS	5.6	5.6	SySM-1	....	like RS
SS	2.8	1.6	C_1	....	9.7
RS	13.0	17.0	C_2	....	28.7
LL	6.3	6.3	K_x	....	11.2

TABLE 2. Results of Factor Analysis of Pooled Correlation Matrix.

Character	Proportion of variance unexplained by general size, $1-p^2_{i.g.}$	High (>.30) residual partial correlation coefficients (general size kept constant)
A	0.10	$r_{AB.g}=.38$
B	.21	$r_{AB.g}=.38$
C	.33	$r_{CD.g}=.32$
D	.30	$r_{CD.g}=.32$
E	.74	
F	.99	
G	.82	
J	1.00	
K	1.00	
L	.12	
M	.47	
N	.31	
O	.60	$r_{OP.g}=.47$
P	.61	$r_{OP.g}=.47$

RESULTS AND DISCUSSION

Table 3 shows the means, average standard errors and sample sizes of all the characters measured for all the flies in the study. When comparing differences among the means with standard errors of the latter it becomes evident that there is considerable heterogeneity among the strain means for every character and for both series of measurements. A clearer view of these relationships can be obtained from Table 4 which summarizes the results of numerous analyses of variance performed on the offspring of both sexes of series I and on the female parents and offspring of series II. We note in line 3 of Table 4 that there are significant differences among strains for every character studied by us. It can therefore be deduced that the characters measured in this study were affected by genetic variation, and that the genetic differences among the strains of our study are reflected in

TABLE 3. Means, Average Standard Errors and Sample Sizes for Two Series of Measurements of 14 Characters of 14 Strains of *D. melanogaster*.

	Sample Size					A					B			C		
Series	I♀P	I♀O	I♂O	II♀P	II♀O	I♀P	I♀O	I♂O	II♀P	II♀O	I♀P	I♀O	I♂O	I♀P	I♀O	I♂O
Strain																
PP	15	33	33	35	35	2.147	2.255	1.989	2.040	2.177	.982	1.046	.948	.698	.728	.693
CP	20	33	33	35	35	2.146	2.297	2.048	2.074	2.216	1.044	1.080	.986	.695	.730	.698
BS	20	33	33	35	35	1.996	2.244	1.988	2.074	2.196	.963	1.085	.963	.643	.725	.692
NS	8	33	33	35	35	2.213	2.260	1.982	1.971	2.143	1.017	1.057	.947	.728	.730	.687
SS	15	33	33	35	35	1.965	2.216	1.969	1.957	2.165	.941	1.053	.946	.655	.705	.675
RS	....	33	33	35	35	.....	2.244	1.973	1.907	2.160	.....	1.060	.942	.....	.725	.687
LL	8	33	33	35	35	2.289	2.334	2.058	2.029	2.177	1.089	1.117	.981	.722	.739	.696
SL	7	33	33	35	35	2.044	2.258	1.980	1.904	2.090	.910	1.046	.918	.654	.712	.670
CS	....	33	33	35	35	.....	2.261	2.000	1.862	2.185	.....	1.049	.958	.....	.727	.691
SyS-102	....	....	....	35	35	.....	.....	.....	1.962	2.188	.....	.....	.....	.....	.....	.....
SySM-1	....	....	....	35	35	.....	.....	.....	2.001	2.199	.....	.....	.....	.....	.....	.....
C_1	....	....	....	35	35	.....	.....	.....	1.982	2.132	.....	.....	.....	.....	.....	.....
C_2	....	....	....	35	35	.....	.....	.....	1.973	2.035	.....	.....	.....	.....	.....	.....
K_x	....	....	....	35	35	.....	.....	.....	2.115	2.126	.....	.....	.....	.....	.....	.....
Average Standard Error[1]						.0981	.0094	.0094	.0129	.0129	.0496	.0056	.0056	.0367	.0036	.0036

TABLE 3 (continued)

Series	D					E			F				
	I♀P	I♀O	I♂O	II♀P	II♀O	I♀P	I♀O	I♂O	I♀P	I♀O	I♂O	II♀P	II♀O
Strain													
PP	.714	.743	.708	.646	.698	.333	.341	.342	.0856	.0924	.0893	.0860	.0902
CP	.685	.748	.708	.666	.708	.341	.343	.333	.0894	.0946	.0917	.0881	.0915
BS	.634	.743	.704	.666	.704	.309	.341	.329	.0840	.0891	.0908	.0871	.0908
NS	.744	.738	.702	.640	.685	.339	.344	.330	.0904	.0885	.0903	.0844	.0906
SS	.662	.717	.685	.628	.690	.306	.336	.319	.0819	.0888	.0884	.0844	.0896
RS	.....	.738	.695	.620	.715	.....	.348	.337	.....	.0897	.0908	.0856	.0921
LL	.736	.754	.712	.654	.702	.353	.358	.347	.0904	.0912	.0916	.0860	.0921
SL	.672	.734	.689	.623	.678	.302	.348	.339	.0762	.0862	.0874	.0831	.0883
CS	.....	.735	.705	.594	.682	.....	.338	.329	.....	.0871	.0866	.0827	.0912
SyS-102	.....	.....	.....	.618	.704	.....	.....	.....	.....	.....	.....	.0869	.0948
SySM-1	.....	.....	.....	.635	.701	.....	.....	.....	.....	.....	.....	.0862	.0931
C_1	.....	.....	.....	.635	.697	.....	.....	.....	.....	.....	.....	.0881	.0937
C_2	.....	.....	.....	.651	.670	.....	.....	.....	.....	.....	.....	.0883	.0898
K_x	.....	.....	.....	.706	.704	.....	.....	.....	.....	.....	.....	.0917	.0935
Average Standard Error[1]	.0367	.0038	.0038	.0042	.0042	.0314	.0044	.0044	.01010	.00089	.00089	.00050	.00050

TABLE 3 (continued)

	G					J					K		
Series	I♀P	I♀O	I♂O	II♀P	II♀O	I♀P	I♀O	I♂O	II♀P	II♀O	I♀P	I♀O	I♂O
Strain													
PP	.157	.145	.136	.141	.155	5.16	5.38	5.66	5.60	5.74	2.27	2.91	2.75
CP	.140	.159	.152	.148	.162	5.03	5.97	6.06	5.65	6.28	2.24	3.13	2.86
BS	.141	.164	.157	.146	.154	5.37	5.97	6.03	5.68	5.99	2.68	3.19	3.08
NS	.157	.163	.159	.146	.154	5.49	5.51	5.54	5.71	5.65	2.73	2.86	2.69
SS	.135	.157	.149	.147	.155	5.03	5.44	5.38	5.34	5.54	2.08	2.65	3.02
RS	.....	.161	.156	.145	.156	.....	5.85	5.87	5.32	5.54	.....	3.02	2.96
LL	.159	.166	.155	.146	.167	5.09	5.73	5.66	5.43	5.82	2.30	2.83	2.96
SL	.159	.166	.155	.142	.157	4.54	5.78	5.79	5.77	5.71	2.09	2.95	2.93
CS	.....	.162	.155	.143	.160	.....	5.69	5.94	5.34	5.31	.....	2.96	3.02
SyS-102	.....	.....	.....	.142	.155	.....	.....	.....	5.57	5.85	.....	.....	.....
SySM-1	.....	.....	.....	.141	.155	.....	.....	.....	5.43	5.43	.....	.....	.....
C_1	.....	.....	.....	.148	.158	.....	.....	.....	5.37	5.17	.....	.....	.....
C_2	.....	.....	.....	.149	.155	.....	.....	.....	5.34	5.60	.....	.....	.....
K_x	.....	.....	.....	.154	.152	.....	.....	.....	5.65	5.82	.....	.....	.....
Average Standard Error[1]	.0180	.0013	.0013	.0013	.0013	.2090[2]	.0131[2]	.0131[2]	.0185[2]	.0185[2]	.3622[2]	.0278[2]	.0278[2]

TABLE 3 (continued)

	L			M			N			O				
Series	I♀P	I♀O	I♂O	I♀P	I♀O	I♂O	I♀P	I♀O	I♂O	I♀P	I♀O	I♂O	II♀P	II♀O
Strain														
PP	.734	.769	.684	.297	.300	.273	.445	.454	.426	20.93	22.52	18.06	22.29	23.37
CP	.746	.768	.691	.299	.300	.277	.437	.455	.423	23.05	23.94	18.85	22.54	24.51
BS	.686	.778	.691	.273	.302	.286	.418	.483	.450	19.75	21.70	16.76	23.19	22.63
NS	.733	.768	.683	.285	.302	.278	.457	.463	.428	24.12	23.15	18.06	20.74	21.57
SS	.667	.761	.662	.264	.286	.260	.392	.446	.404	20.80	23.97	19.12	21.11	21.20
RS	.....	.774	.677	.....	.304	.275	.....	.482	.437	.....	23.12	19.03	21.46	23.20
LL	.768	.789	.704	.311	.328	.296	.469	.484	.448	20.75	21.70	16.97	20.51	21.00
SL	.666	.754	.669	.270	.300	.274	.425	.457	.419	18.00	21.55	18.36	20.80	21.83
CS	.....	.757	.674	.....	.316	.284	.....	.466	.429	.....	22.85	17.46	18.80	22.71
SyS-102	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.43	23.66
SySM-1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.23	21.20
C_1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.63	19.71
C_2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.09	21.43
K_x	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.29	23.43
Average Standard Error[1]	.0538	.0038	.0038	.0257	.0024	.0024	.0274	.0023	.0023	3.68	.34	.34	.36	.36

TABLE 3 (continued)

Series	P		
	I♀P	I♀O	I♂O
Strain			
PP	18.87	20.21	18.46
CP	21.90	22.58	19.97
BS	20.60	20.46	18.39
NS	21.25	22.18	19.30
SS	22.13	22.61	19.46
RS	.....	21.33	19.09
LL	18.88	20.21	17.88
SL	17.29	20.88	18.36
CS	.....	21.88	19.09
SyS-102	.....	.....	.....
SySM-1	.....	.....	.....
C_1	.....	.....	.....
C_2	.....	.....	.....
K_x	.....	.....	.....
Average Standard Error[1]	3.71	.36	.36

All linear measurements are expressed in millimeters. Letters across top of table refer to characters mentioned in text. The series are identified by a code symbol listing first the series number, then the sex and finally whether parent or offspring generation. Thus II♀O means female offspring of series II.

[1] In the I♀P series the average standard deviation of items is given in place of the average standard error of the mean, since the means are based on varying sample sizes.

[2] Applicable only to square roots of given means.

differences for these characters. The magnitude and relative position of these differences, however, are not fixed as can be seen from the test for generation-strain interaction in series II. We note that for every character measured the strain-generation interaction was highly significant, meaning that relative metric differences were not maintained from generation to generation.

As regards our primary objective, the investigation of morphological differences correlated with resistance, we divided the strains of series I into three categories: the non-resistant one, namely the CP and SS strains; the intermediate resistant ones (PP, BS, NS, LL, SL and CS strains); and the single resistant strain (RS). The justification for such a categorization can be found in Table 1. If resistance is correlated with morphology one may expect that the mean square for differences in resistance should be significant. The two degrees of freedom for differences in resistance are subdivided into a linear and a quadratic component with one degree each. A linear relation between resistance with a morphological characteristic should result in the linear component being significant while the quadratic one is not. An examination of Table 4 shows that for characters C,D,E,F,L,M,N,O and P the quadratic component was significant (line 8) and this is borne out by the complicated relations of the means to each other, as shown in line 6 of the same table. Only for characters A,B,E,G and J can clear association be shown between resistance and morphological measurement. In characters E and J the resistant means are larger while in the other characters the non-resistant means are larger. These findings appear to differ from those of Bochnig (1956) to the effect that all characters, except the tibia, were increased in length in the resistant strains.

For series II the strains were divided into only two groups. The resistant group included RS, SyS-102, SySM-1, C_1, C_2 and K_x, while the non-resistant group was composed of the other eight strains of the study. Characters A, F, J, and O showed significant morphological differences between the resistant and nonresistant group while in characters D and G the differences were not significant. A significant interaction between generation and resistance in series II was shown for characters A and J. When the two series are compared with each other the results are not at all homogeneous. Only for character A can we conclude that in both series non-resistant flies had longer wings than resistant flies. In all other characters the results were inconclusive or significant differences occurred in opposite directions for the two series. Additional studies correlating the resistance rank of a given strain with the rank of its mean by the method of rank correlations (see Siegel, 1956), yield high, positive and significant correlations for G ♂, M ♀, M ♂, N ♀ and N ♂ in series I but only one significant and negative correlation in series II. Again we cannot establish consistent patterns of response. It appears therefore that no general, reliable correlation between larval resistance to DDT in the medium and the morphological characters measured can be found.

When the various families of strains are examined separately, considerably more stability from series to series and from parent to offspring is found. In the pupation site strains we find that the CP flies are consistently

larger for every measurable character than are the PP flies (Table 4, line 10). Only one significant strain-generation interaction is found for these strains (Table 4, line 11). The larger size of the CP line may be interpreted by a longer or more intensive period of food uptake when compared with the PP line. In comparative studies of larval behavior between the two strains (Sokal, 1959) it was found that the CP larvae burrowed into the medium considerably earlier than PP larvae and that the latter apparently had a higher metabolic rate. It may therefore be assumed that the CP larvae are larger since they feed more and earlier and also since they may not use up as much food for energy as do the PP larvae. Yet another reason for explaining the larger size of the CP flies may be the following: it has been shown that late pupating larvae are more often central than peripheral (Sokal *et. al.*, 1959). Although we have never been able to demonstrate a difference in length of larval period between the CP and PP lines, it may still be that slight differences do exist and that these differences in larval period are sufficient to induce differences in size. It is well known that larval period differences produce differences in size. A case in point is Table 4, where line 14 shows an analysis of Dr. Hunter's larval period strains. It is also well known from general insect physiology studies that many insects reared at low temperatures and therefore taking a longer period for development are considerably larger than their counterparts reared at higher temperatures.

When we examine the RS, NS and SS strains, we find that the differences for various characters are no longer clear cut. Not only do the size relations differ from character to character but they also differ from series to series (Table 4, line 12) and strain-generation interaction is present in two characters (Table 4, line 13). These findings bear out our doubt, expressed earlier, whether meaningful correlations between DDT-resistance and morphological characters can be established. Perhaps the only consistent character is F (length of the fourth metatarsus) which appears to have the same size relations for the three strains for both series, as well as for parent and offspring generations.

It has already been mentioned that the strains differing in length of larval period developed by Dr. Hunter differed in size in a fairly consistent pattern. The LL strain was larger than the SL strain for almost all characters. The CS strain differed in its position, being either between the two selected strains or on either side of them. This corroborates the generally unstable and fluctuating position of the CS strain (Hunter, 1959). Only for the two bristle characters J and O was the SL mean greater than the LL mean.

While Tables 3 and 4 provide information on the relative magnitude of the means and the significance of the differences between means in several of the strains from Dr. King's and Dr. Crow's laboratories, we cannot say much about the consistency of such differences, since they were measured only in one series. If one may judge from the presence of strain-generation interaction for many of the characters it would appear that the established morphological differences among these strains would not remain stable.

When we correlate the means of parents and of offspring for a given

character over all the strains that were studied, we obtain a measure of the stability of the particular character. Thus, if the relative positions of the strains as regards magnitude of a given character remain the same in the offspring as they were in the parent generation, a very high correlation should ensue. It is convenient and expeditious to use ranking methods of correlation, such as Spearman's rank correlation coefficient (r_s) when we are trying to associate two groups (e.g. parents and offspring), and to use the Kendall coefficient of concordance (W) when we are trying to find the mutual covariation of three or more groups. These methods are described in detail in Siegel (1956). Table 5 lists the parent-offspring rank correlations for all characters measured in series I and series II as well as the coefficients of concordance of the female offspring of series I with the female parents and offspring of series II. Characters A,C,L,O, and P are significantly correlated between parents and offspring in series I while only F, J, and O are significantly correlated in series II. When the coefficients of concordance for the three groups are examined we find that only characters D and F have significant values of W while some others, such as A, J and O, are large and suggestive, but not significant.

Of the characters investigated it appears that A, F and O are the most stable. A, which is the wing length, seems to be an excellent measure of general size from our factor analysis and the relative size of the various strains appears to vary but little. That wing length is a good measure of general size is borne out by independent studies carried out by Robertson and Reeve (1952). The fourth metatarsus (F) appears to be an independent dimension of variation in *Drosophila* and quite stable in its expression from generation to generation. Finally, bristle number (O) is a character that has been studied extensively by a number of authors in recent years. Its relative stibility in the absence of strong environmental or selective forces has been demonstrated repeatedly and it is therefore not surprising that our strains, which had not been selected for this character, should exhibit considerable stability of the magnitude of bristle number over several generations. Similarly characters P and L which were not measured in series II had high rank correlation coefficients.

The data on Tables 3 and 4 present as a by-product useful measurements of a number of characters in *Drosophila melanogaster* and the ranges which these characters assume in a heterogeneous group of strains; differences between the sexes are also shown. The female measurements are larger than the male ones except for character J (the number of dorsal setae on the arista of the antenna).

The inconclusive results of relating resistance in *Drosophila* to morphological differences corresponded with the results obtained by Sokal and Hunter (1955) on the housefly *Musca domestica*. In the latter case it was argued that a number of different genetic systems had become established in the different housefly strains and that, since it was unlikely that different genetic systems had identical morphological correlates it would not be reasonable to assume correlation between morphology and DDT-resistance. In the *Drosophila* strains discussed above the genetic history of the strains is considerably better known than in the case of the houseflies and it can

TABLE 4. Results of Analyses of Variance on Offspring (both Series I a

Source of Variation	Series	A I	A II	B I	C I	D II
Sex (Series I)		♀>♂**	—	♀>♂**	♀>♂**	—
Generation (Series II)		—	**	—	—	**
Strains		**	**	**	**	**
Sex-Strain Interaction (Ser. I)		N.S.	—	**	N.S.	—
Generation-Strain Interact. (Ser. II)		—	**	—	—	**
Res. vs. Non-res.		R<N**	R<N*	R<N*	I>R,N*	N.S.(R<
Linear Component (Ser. I)		*	—	**	N.S.	—
Quadratic Component (Ser. I)		N.S.	—	N.S.	*	—
Res.-Gen. Interact. (Ser. II)		—	*	—	—	N.S.
Pupation Site Strains		CP>PP**	CP>PP**	CP>PP**	N.S.	CP>PP
Strain-Gen. Interact. (Ser. II)		—	N.S.	—	—	N.S.
Resistance Strains		NS>RS>SS**	N.S.(SS>NS>RS)	N.S.	NS>RS>SS**	N.S.(RS>N
Strain-Gen. Interact. (Ser. II)		—	**	—	—	**
Larval Period Strains		LL>CS>SL**	LL>CS>SL**	LL>CS>SL**	LL>CS>SL**	LL>SL>
Strain-Gen. Interact. (Ser. II)		—	**	—	—	**
J. C. King's Strains (Ser. II)		—	102<M_1*	—	—	102<M
Strain-Gen. Interact. (Ser. II)		—	N.S.	—	—	**
J. F. Crow's Strains (Ser. II)		—	K_x>C_1>C_2**	—	—	K_x>C_1>
Strain-Gen. Interact. (Ser. II)		—	**	—	—	**

Source of Variation	Series	J I	J II	K I
Sex (Series I)		♀<♂*	—	N.S.
Generation (Series II)		—	**	—
Strains		**	**	**
Sex-Strain Interaction (Ser. I)		N.S.	—	*
Generation-Strain Interact. (Ser. II)		—	**	—
Res. vs. Non-res.		R>N*	R<N**	N.S.
Linear Component (Ser. I)		*	—	N.S.
Quadratic Component (Ser. I)		N.S.	—	N.S.
Res.-Gen. Interact. (Ser. II)		—	N.S.	—
Pupation Site Strains		CP>PP**	CP>PP**	N.S.
Strain-Gen. Interact. (Ser. II)		—	**	—
Resistance Strains		RS>NS>SS**	NS>SS>RS**	N.S.
Strain-Gen. Interact. (Ser. II)		—	N.S.	—
Larval Period Strains		N.S.(CS>SL>LL)	SL>LL>CS**	N.S.
Strain-Gen. Interact. (Ser. II)		—	*	—
J. C. King's Strains (Ser. II)		—	102>M_1**	—
Strain-Gen. Interact. (Ser. II)		—	N.S.	—
J. F. Crow's Strains (Ser. II)		—	K_x>C_2>C_1**	—
Strain-Gen. Interact. (Ser. II)		—	*	—

EXPLANATIONS OF SYMBOLS:

** = $P \leqq .01$, * = $.01 < P \leqq .05$, N.S. = $P > .05$

The table entries for fixed effect comparisons are an attempt to give not only the significance level but also the nature of the differences. Thus ♀ > ♂ ** means that the females have a greater mean than the males and that this difference is significant at $P \leqq .01$. The symbols used in this notation are the conventional ones for sex, the pre-

ng (both Series I and Parents and Offspring (females only) of Series II.

	D	E		F		G	
	II	I	I	II	I	II
**	—	♀>♂**	N.S.	—	♀>♂**	—
	**	—	—	**	—	**
	**	**	**	**	**	**
	—	N.S.	*	—	N.S.	—
	**	—	—	**	—	**
*	N.S.(R<N)	R>N*	I<R,N**	R>N**	R>N**	N.S.(R<N)
	—	*	N.S.	—	**	—
	—	*	**	—	N.S.	—
	N.S.	—	—	N.S.	—	**
N	CP>PP**	N.S.	CP>PP**	CP>PP**	CP>PP**	CP>PP**
	N.S.	—	—	N.S.	—	N.S.
SS** NS	N.S.(RS>NS>SS)	RS>NS>SS**	RS>NS>SS**	RS>NS>SS**	NS>RS>SS**	N.S.(SS>RS>NS)
	**	—	—	N.S.	—	N.S.
SL** L	LL>SL>CS**	LL>SL>CS**	LL>CS=SL**	CS>LL>SL**	N.S.(LL>SL>CS)	LL>CS>SL**
	**	—	—	**	—	N.S.
	102<M_1*	—	—	102>M_1*	—	N.S.
	**	—	—	**	—	N.S.
	K_x>C_1>C_2**	—	—	K_x>C_1>C_2*	—	N.S.
	**	—	—	**	—	**

	M	N	O		P
	I	I	I	II	I
	♀>♂**	♀>♂**	♀>♂**	—	♀>♂**
	—	—	—	**	—
	**	**	**	**	**
	*	**	N.S.	—	N.S.
	—	—	—	**	—
	I>R,N**	R>N**	I<R,N**	R<N*	I<R,N**
	**	**	N.S.	—	**
	**	**	**	—	**
	—	—	—	N.S.	—
	N.S.	N.S.	CP>PP**	N.S.(CP>PP)	CP>PP**
	—	—	—	N.S.	—
**	RS=NS>SS**	RS>NS>SS**	SS>RS>NS*	RS>NS=SS**	N.S.
	—	—	—	N.S.	—
**	LL>CS>SL**	LL>CS>SL**	CS>SL>LL*	N.S.(SL>CS=LL)	CS>SL>LL**
	—	—	—	**	—
	—	—	—	102>M_1**	—
	—	—	—	N.S.	—
	—	—	—	K_x>C_2>C_1*	—
	—	—	—	N.S.	—

viously stated abbreviations for the strain names and the following: N = nonresistant, R = resistant, I = intermediate in resistance, 102 = SyS-102, M_1 = SySM-1. Directions of non-significant differences between means are given only where they can be compared with significant differences for the same character in the other series. Letters across top of table refer to characters mentioned in text. Mean squares and degrees of freedom are not shown in order to conserve space.

be shown rather definitely that we are dealing with very different genetic systems in these strains. It is therefore not very surprising that no overall correlation with resistance can be maintained.

The similarity of the experimental design in the present study with that of the housefly research invites comparison of some of the other findings not necessarily related to DDT-resistance. We find that the major dimensions of the pooled correlation matrix which are obtained by the simple factor analysis are very similar in the two flies. The only difference appears to be that in the housefly character L (the length of the scutum) is a meaningful and important dimension while in *Drosophila* character F (the length of the fourth metatarsal segment) emerged instead. In comparing Table 2 of the *Drosophila* study with Table III in the housefly paper we find that general size can explain more of the variance of the *Drosophila* characters than of the housefly characters. As previously mentioned character F (fourth metatarsal length) appears to be an entirely independent dimension in the *Drosophila,* while in the houseflies it was affected to an appreciable degree by general size. On the other hand N (the distance between the inner margins of the eyes) is considerably less variable in *Drosophila* and more affected by general size. The wellknown sex difference in the houseflies for

TABLE 5. Stability of Characters as Demonstrated by Rank Correlation of Means.

Character	Parent-Offspring Correlation Series I *Drosophila* r_s	Parent-Offspring Correlation Series II *Drosophila* r_s	Concordance among Series I, ♀ offspring and Series II ♀ parents and offspring *Drosophila* W	Correlation between series of measurements in homologous housefly characters (data by Sokal and Hunter, 1955) r_s
A	.822*	.282	.542	.263
B	.667			
C	.739*			
D	.360	.251	.745*	.114
E	.414			
F	.414	.464*	.732*	
G	.661	—.105	.375	—.143
J	—.179	.607*	.598	.143
K	.215			
L	.721*			.600
M	.580			
N	.595			
O	.739*	.480*	.510	.454
P	.775*			
X_5				.600*
X_7				.809

r_s=Spearman rank correlation coefficient.

W=Kendall coefficient of concordance.

*=coefficient significant at $P \leqq .05$.

X_5=ratio of maximum width of second abdominal sternum divided by its maximum length in the housefly.

X_7=ratio G/N in the housefly.

N affected our data. Wing length and width appears to be a much better representative of general size in *Drosophila* than it is in the housefly.

When housefly characters are examined for stability of ranks of means between series of measurements the values shown in the last column of Table 5 were obtained. From these it would appear that only L among the measurements or counts appeared to have an appreciable rank correlation coefficient. This compares well with the significant correlation coefficient for L during the only series in which it was possible to compute it in *Drosophila*. Both ratios computed in the housefly have high rank correlation coefficients although only one of these could be shown to be significant. Note that the ratios proved to be more stable than the ordinary measurements; inherently ratios are less reliable than direct measurements. We may assume, therefore, that these ratios represent examples of homeostasis for body proportions and general body shape. The housefly rank correlations are all somewhat lower than those of *Drosophila*. This may be explained in that the *Drosophila* correlations are between parents and offspring, while those of the houseflies are a number of generations apart.

The nature of the fluctuations observed in this study is puzzling and appears to belong to a field of relatively little studied gene-environment interactions. We cannot preclude the possibility of major genetic change over the period of sixteen months. As a matter of fact it would be reasonable to expect such change. On the other hand the presence of gene environment interaction as shown by the generation-strain interactions in several lines of Table 4 demonstrates that very rapid changes in general position of strain means are to be expected. This has also been our experience in the housefly work and in various selection studies in *Drosophila*. We are far from a solution of this matter, but some attempts at isolating the components of this interaction have been made (Schlager, 1959).

SUMMARY

1) Measurements were taken on 1667 flies from 14 different strains of *D. melanogaster*. Six of these strains were resistant to DDT in the larval medium and eight were non-resistant. The measurements represent two series of flies reared 16 months apart.

2) Fourteen morphological characters were measured. Neither all characters nor all strains were measured in both series. Each series consists of female parents and their female offspring. In series I male offspring were measured as well.

3) A crude factor analysis was performed in order to secure characters representative of the primary common factors causing variation in the characters studied.

4) Means and average standard errors for characters of the strains of both series are listed in Table 3. The data were subjected to analyses of variance and the results are shown in Table 4. Strain means are significantly different for all characters in both series. While significant morphological differences between resistant and non-resistant flies can be demonstrated in almost every case, these differences are not consistent in that the relative position of means change from generation to generation and from series to series.

5) In general it may be concluded that DDT-resistance is not correlated

with any of the morphological characters and ratios in this study. This corresponds to the earlier findings of Sokal and Hunter (1955) for an analogous study of the characters of the housefly, *Musca domestica.*

6) It is concluded that the lack of morphological correlates of resistance is due to the manifold genetic origins of the strains tested. The DDT-resistance which exists probably does not have a common physiological base and it can therefore not be expected that morphological correlates will be found.

7) The stability of strain means for three families of strains is further investigated and it can be shown that both the pupation site strains (CP, PP) and the larval period strains (SL,LL,CS) remain relatively stable in the expression of morphological differences. The resistance selected strains (SS,RS,NS) are considerably less stable in this regard.

8) A study is made of the stability of characters from generation to generation and over the study as a whole. It is concluded that wing length, fourth metatarsal length, metatibia length and setae on the fourth abdominal sternite are the most stable of the characters in the study in terms of maintaining their relative magnitude over a period of time.

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A NEW SPECIES OF *CALLIBAETIS* FROM KANSAS (Ephemeroptera: Baetidae)[1]

WILLIAM L. PETERS

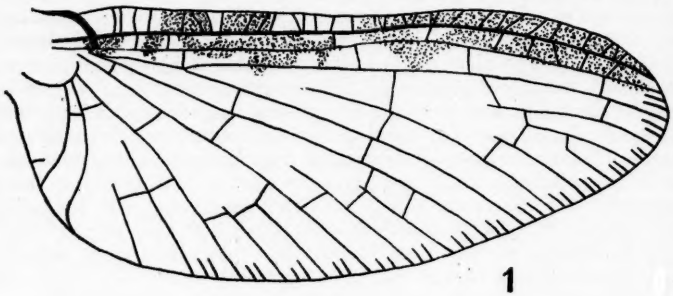
Callibaetis centralis new species

Male imago (in alcohol). Length: body 7-8 mm., wing 8-8.5 mm. Antennae: scape brown, proximal portion of pedicel brown, distal portion dark brown, flagellum light brown, apical one-third white. Eye: upper portion dark green, stalk medium buff, lower portion gray with a darker longitudinal band. Ocelli white. Head brown. Thorax: dorsum dark brown, pleural area of mesothorax and metathorax medium buff with many small brown spots, sutures dark brown. Venter brown with medium buff areas medially. Fore leg: white marked with brown; coxa light brown, darker proximally; trochanter white washed lightly with brown; femur white with anterior margin brown, six large brown spots laterally and faint brown markings on medial surface; tibia light brown, darker at tip, articulation of femur and tibia dark brown; first tarsal segment light brown, other segments white, tarsal joints brown, pretarsus light brown. Middle and hind legs: coxa white; trochanter dark brown; femur light brown with ten brown spots laterally; tibia white with both articulations brown; transverse brown band on proximal portion of tibia; tarsus white with brown joints, pretarsus light brown. Wings (figs. 1 and 2): longitudinal veins and border vein brown, fading out in cubital area. Cross veins in cell R_1 white, others brown, fading out in cubital area; many cross veins in fore wing. Marginal intercalaries in pairs. Stigmatic area white, remainder of wing membrane hyaline. Abdomen: tergites medium brown with many dark brown spots and with dark brown posterior margins. Dark brown spiracular spots on each segment. Genitalia (fig. 3): basal segment of forceps light brown, tip of fourth segment brown, remainder of forceps white; constriction at articulation of second and third segment. Tail: white with dark brown annulations at articulations.

Female imago (in alcohol). Length: 6.5-7.5 mm., wing 6.5-7.5 mm. Antennae: scape and pedicel medium buff at base, remainder reddish brown, flagellum white at base, remainder dark brown. Eye: green with one dark green longitudinal band. Ocelli: green with narrow black band around base. Head: medium buff with two longitudinal reddish brown bars between eyes. Thorax: pronotum and mesonotum medium buff, sutures brown; metanotum anteriorly medium buff, posteriorly brown. Pleural area medium buff, sutures brown, some sclerites washed with light brown. Sternum pale buff; sternum of prothorax completely covered by many small brown spots; sternum of mesothorax and metathorax with small brown spots only in medial area. Fore leg: coxa medium buff, washed with reddish brown; trochanter buff; femur buff washed lightly with brown, with many large brown spots laterally; tibia white, tip black, articulation with femur black;

[1] Contribution No. 1053 from the Department of Entomology, The University of Kansas, Lawrence, Kansas. This investigation was supported by a grant from the Kansas Heart Association.

tarsus and pretarsus black. Middle and hind legs: coxa and trochanter medium buff with a few small brown spots; femur white with nine to twelve large brown spots, its anterior and posterior borders brown; tibia white, articulations brown; first tarsal segment white, other segments light brown, darker at articulations, pretarsus brown. Wing: longitudinal veins and border vein brown; cross veins white, fading to hyaline towards cubital area; cross veins in fore wing many; marginal intercalaries in pairs. Membrane of wing with alternating areas of white and brown in costal and discal areas; remainder of wing hyaline. Abdomen: white, dorsum with many small brown spots, large area of brown medially on each segment. A



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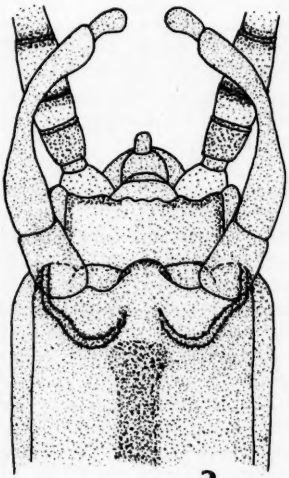

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Callibaetis centralis. Fig. 1. Fore wing of female paratype. Fig. 2. Hind wing of female paratype. Fig. 3. Ventral view of male holotype genitalia.

brown longitudinal line on each lateral edge of tergites, extending entire length of each segment. Venter with many small brown spots and paired brown longitudinal streaks medially; brown spiracular spots on each segment. Tail: white with black annulations at articulations.

Holotype: male imago, The University of Kansas Natural History Reservation, eight miles northeast of Lawrence, Douglas County, Kansas, October 21, 1958, collected by W. L. Peters. Allotype: female imago; same data as that for holotype. Paratypes: two males, thirty-four females; same data as that for holotype. All specimens preserved in alcohol. Holotype, allotype and all paratypes are deposited in the Snow Entomological Museum, The University of Kansas, Lawrence, Kansas.

Callibaetis centralis is closely allied to *C. pictus;* however, both seem to be distinct species. The general coloration of the female of *C. centralis* is medium buff, duller and somewhat darker than that of the yellowish female of *C. pictus*. Close comparison shows that the female of *C. pictus* has a very light brown abdomen, while the female of *C. centralis* has a white abdomen. The abdomen of the male of *C. centralis* is much lighter than that of the male of *C. pictus,* and the annulations of the tail of the former are dark brown, while in *C. pictus* they are gray. The length of the male *C. centralis* is 7-8 mm., whereas it is only 5-6 mm. in *C. pictus*.

In the fore wing of *C. centralis* more cross veins occur in the subcostal area, and the longitudinal veins in the cubital area are not connected with cross veins as in *C. pictus*. In the hind wing the longitudinal and cross veins are also arranged differently.

It is not known if *C. pictus* and *C. pacificus* are synonymous, but *C. centralis* and *C. pacificus* seem to be distinct species.

The naiad and subimago are unknown. Subimagoes were collected, but all molted before being preserved. Subimaginal skins were saved.

Considerable variation was noted among the thirty-five available females. The eyes in some specimens are blue green. Coloration in the disc of the fore wing is absent in several specimens. In one specimen a large brown spot was found anteriorly on each side of each abdominal tergite, medially from the brown longitudinal line.

All specimens of *C. centrails* were collected from a small creek, one to five feet in width and one inch to eight inches deep. The water was slowly flowing in shallow areas and forming deep quiet pools. Bottom type: rock four to five inches in diameter to small gravel. Bottom covered with much algae. All specimens were collected from the underside of a bridge. Specimens were collected between 2:30 and 3:05 p.m., C.S.T.

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SOME NEW SPECIES AND SUBSPECIES OF *CROSSIDIUS* FROM WESTERN NORTH AMERICA (Coleoptera: Cerambycidae)

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The following descriptions are offered at this time in order that the names might be available for use in connection with other studies. The writers are indebted to W. F. Barr of the University of Idaho, R. C. Bechtel of the Nevada Insect Survey, University of Nevada, M. A. Cazier of the American Museum of Natural History, G. F. Knowlton of the Utah State University, J. N. Knull of Ohio State University, F. S. Truxal of the Los Angeles County Museum, G. B. Vogt of the U. S. Department of Agriculture and U. S. National Museum, and to various colleagues at the University of California, notably B. J. Adelson, P. D. Hurd, Jr., D. D. Linsdale, A. T. McClay, J. W. MacSwain, J. A. Powell, and Ray F. Smith, for aid in the making of field collections or for the loan of critical material. Primary types of the species and subspecies described below are deposited in the California Academy of Sciences, except for *C. coralinus obfuscipennis* and *C. rhodopus flavescens* which are in the United States National Museum and the Los Angeles County Museum, respectively.

Crossidius hurdi Chemsak and Linsley, new species

MALE. Form moderately large, robust; color testaceous and black, shining, coarsely densely punctate, moderately pubescent. *Head* densely, moderately coarsely, subconfluently punctate at vertex, less densely on front, small irregular smooth impunctate area on vertex between eyes; pubescence fairly sparse, long, fine and erect; antennae exceeding elytral apices by about 2-3 segments, eleventh segment long, appendiculate; scape clothed with short bristle-like hairs, antennal tubercles prominent, distinctly angulate, pointed at apex. *Pronotum* broader than long, broadly rounded at sides, often with trace of lateral tubercles; surface shining, densely, moderately coarsely, subconfluently punctured, disk with traces of three glabrous calluses; sparsely clothed with long fine erect hairs; prosternum impressed before coxae, deeply densely punctate, densely pubescent; meso- and metasternum finely, moderately punctate, densely clothed with long suberect hairs. *Elytra* slightly less than 2½ times longer than broad, wider than pronotum; black pattern greatly expanded, enveloping apices and extending to about basal one-fourth, sides of marking parallel, somewhat produced along suture anteriorly, black marking with faint bluish cast, humeri black; punctures at base large, dense, contiguous, larger than those of pronotum, becoming finer apically; pubescence moderate, fairly long and suberect, not obscuring surface; apices sinuate-truncate, sutural angle with slight indication of tooth. *Legs* densely, moderately coarsely punctate, moderately pubescent, more so along inner edges; hind femora long, reaching at least to fifth abdominal segment, hind tibiae slightly sinuate. *Abdomen* rufous, finely densely punctate, moderately pubescent, not obscuring surface. Length, 12-17 mm.

FEMALE. Antennae reaching to about mid-elytra or slightly beyond.

Elytra somewhat shorter than body, color pattern same as in male. Length, 13-18 mm.

Holotype male, allotype female and 59 paratypes (29 males, 30 females), Skeleton Canyon, 6 miles SE Apache, Cochise County, Arizona, September 1-4, 1958, on *Haplopappus hartwegi* and *Gutierrezia sarothrae* (P. D. Hurd, E. G. Linsley); additional paratypes are as follows: 3 males, 1 female, Douglas, Cochise County, Arizona, November 5, 1944 (R. Martin); 1 male, Douglas, Arizona, August 25, 1935 (W. W. Jones). Larvae were also taken in the roots of *Haplopappus hartwegi* by P. D. Hurd, for whom the species is named.

This species superficially resembles *C. pulchellus* LeConte and has the pronotum similarly shining, coarsely punctate and not rugose. However, the average size is larger (*pulchellus* ranges from 8-14 mm.) and *hurdi* differs in the distinctly dentiform sutural angle of the elytra and the equally expanded dark areas of the elytra in both sexes (only one of the males in our series has the black markings reduced to a narrow sutural stripe).

Crossidius cerarius Chemsak and Linsley, new species

MALE. Moderate sized, form stout, robust; integument brownish black to black; pubescence dense, somewhat appressed and rather fine; body entirely covered by waxy appearing granules which obscure the surface. *Head* finely densely punctate on vertex; fairly densely covered with long erect pale hairs; very thickly covered by white waxy granules which obscure the entire surface; antennae short, barely attaining elytral apices, distal segments rather densely clothed with short, appressed, golden silky-like pubescence, with waxy granules suffused throughout. *Pronotum* large, wider than long, slightly narrower than elytral bases, sides feebly tuberculate, disk convex, uneven, slightly inflated; pubescence fairly dense, long, pale, erect and suberect, denser at sides; punctation moderate, dense; surface thickly covered by waxy granules which obscure the surface; prosternum coarsely, deeply punctate except for anterior impunctate band, pubescence dense, long, suberect; meso- and metasternum finely densely punctate, densely pubescent. *Elytra* about 2.2 longer than broad; finely, rather densely punctate at base, more finely toward apex; unicolorous, without vittae; pubescence fairly long, pale, suberect, rather thickly covered by waxy granules which together with the pubescence, obscure the surface; apices obliquely truncate. *Legs* with femora moderately coarsely, densely, shallowly punctate; pubescence fairly dense, long, pale, and suberect. *Abdomen* densely clothed with long pale appressed pubescence which obscures the surface, waxy granules present; last abdominal sternite broadly shallowly rounded. Length, 13.5 mm.

FEMALE. Antennae barely attaining mid-elytra; last abdominal sternite truncate. Length, 14 mm.

Holotype male, allotype female, 3 miles south Currie, Elko County, Nevada, August 14, 1958, out of roots of *Chrysothamnus viscidiflorus* (R. W. Lauderdale).

C. cerarius is one of the most distinctive members of the genus. The body is clothed with a pale waxlike covering which gives the insect a dusty

appearance. The short robust form is also characteristic. It is apparently related to *C. allgewahri* LeConte.

Crossidius coralinus tejonicus Chemsak and Linsley, new subspecies

Form and size of *C. coralinus ruficollis* Linsley but bright red with bluish markings. Elytral pattern of male much broader and more uniform in a series. Female with coarser pronotal punctation. Approaching *C. coralinus ascendens* Linsley in coloration and pattern but differing by the following characters: *Male:* Punctation at base of elytra much larger and coarser, punctures separated by less than their own width; pronotum more coarsely closely punctate; elytral pattern much broader, extending outward from suture. *Female:* Pronotum between dorsal calluses very coarsely confluently punctate directly behind apex; elytral marking not exceeding apical two-thirds; basal black band of elytra not as wide, not covering humeri as broadly.

Holotype male, allotype female, and 55 paratypes (31 males, 22 females), Lebec, Kern County, California, October 4, 1957 and October 10, 1958, on *Chrysothamnus nauseosus mojavensis* (J. A. Chemsak, J. W. MacSwain, W. E. Ferguson). Additional paratypes are as follows: 3 males, 3 females, Lebec, September 5, 1932 (F. T. Scott); 2 males, Lebec, September 21, 1935 (L. J. Muchmore, J. A. Corcoran); 1 male, Fort Tejon, Kern County, California, October 4, 1957 on *Chrysothamnus nauseosus mojavensis* (J. W. MacSwain). Additional specimens not designated as paratypes: 1 female, Cuyama Valley, Ventura County, California, October 18, 1952 (K. W. Tucker); 7 males, 7 females, Mill Potrero, Kern County, California, September 3, 1956 (A. Menke, Hess); 1 male, three miles west of Frazier Mountain Park, Kern County, California, August 27, 1956 (A. Menke and Hess).

This subspecies occurs in the ridge area of the Tehachapi Mountains.

Crossidius coralinus ferruginosus Chemsak and Linsley, new subspecies

Form of *C. coralinus ruficollis* Linsley but more robust and pale reddish brown in color. Differs from that subspecies by the following characters: *Male:* Pronotum shining to the naked eye; basal elytral punctures coarser, approaching those of pronotal disk in size. *Female:* Punctures on pronotal disk large, not as confluent, disk not rugous, smoother; basal elytral punctures coarser, more widely spaced and less rugous in appearance; pronotum shining; marking of elytra black, hardly tinged with blue.

Distinguished from *C. coralinus ascendens* Linsley by the much paler reddish color, less shining appearance and thicker punctation at elytral base, and from *C. coralinus tejonicus* by the paler reddish color, reduced male elytral markings, and absence of blue overtones in the elytral pattern.

Holotype male, allotype female and 58 paratypes (51 males, 7 females), Firebaugh, 5 miles west and 4 miles west, Fresno County, Califorina, September 8 and 9, 1948 and September 22, 1948, on *Haplopappus venetus* (R. F. Smith). Additional specimens are as follows: 68 males and 15 females, Mendota, Fresno County, California, July 15 and August 8 (F. T. Scott), September 11, 1947 on *Haplopappus venetus* (V. M. Stern); 24 males and 15 females, 2 miles NW. Mendota, September 23, 1947 (R. V. d.

Bosch), October 20, 1952, on *Haplopappus acradenius bracteosus* (R. F. Smith, T. F. Leigh), October 17, 1956 on *H. acradenius bracteosus* (R. F. Smith, K. S. Hagen).

Crossidius coralinus fulgidus Chemsak and Linsley, new subspecies

Form and size of *C. coralinus ruficollis* but bright red with expanded black elytral pattern in both sexes. *Male:* Moderately shining; punctation of pronotum very coarse, confluent, giving disk a rugose appearance; elytral punctation very large, contiguous at base, almost exceeding largest punctures of pronotal disk; sutural angle slightly dentate at apex; elytral marking enveloping apices and extending to about basal one-third, pointed anteriorly along suture; basal black band somewhat narrow, covering humeri. *Female:* Coloration as in male; elytral pattern slightly broader anteriorly; pronotal punctation large, confluent, with indications of punctate dorsal calluses, disk rugose; basal elytral punctures very coarse, almost confluent.

Differing from *ascendens* by the brighter, deeper red ground color and black markings without a bluish caste, and the punctation of the pronotum and elytra much more dense and coarse; from *tejonicus* by the brighter red ground color, lack of a bluish caste to its black elytral markings, and its much coarser pronotal and elytral punctation.

Holotype male, allotype female and 15 paratypes (9 males, 6 females), Myton, Duchesne County, Utah, August 26 and 27, 1957 (G. F. Knowlton). Additional paratypes are as follows: 2 males, 1 female, Roosevelt, Duchesne County, Utah, August 27, 1957 (G. F. Knowlton); 11 males, 1 female, Fort Duchesne, Uintah County, Utah, August 27, 1957 on *Chrysothamnus* (G. F. Knowlton); 2 females, Randlett, Uintah County, Utah, August 27, 1957 on *Chrysothamnus* (G. F. Knowlton); 3 males, 2 females, Gusher, Uintah County, Utah, August 27, 1957 on *Chrysothamnus viscidiflorus* (G. F. Knowlton); 4 males, 1 female, Vernal, Uintah County, Utah, August 28, 1957 (G. F. Knowlton); 1 male, Ouray, Uintah County, Utah, August 28, 1957 (G. F. Knowlton). Additional specimens not designated as paratypes were: 2 males, Fort Duchesne, Uintah County, Utah, August 13, 1926, and August 16, 1927 (W. Sorenson). This subspecies occurs in Northeastern Utah.

Crossidius coralinus obfuscipennis Chemsak and Linsley, new subspecies

Form and color of *coralinus coralinus,* varying considerably in size. Elytral pattern extensive, blue-black, often covering entire elytra in the female, abdomen rufous. *Male:* Black elytral pattern reaching at least to the basal one-third, broad laterally; basal dark band usually broad, covering humeri; pronotum distinctly laterally tuberculate, disk coarsely confluently punctured, uneven with traces of five dorsal calluses, pubescence very sparse, thin; elytral base coarsely contiguously punctured, punctures subequal to pronotal ones, pubescence very short, suberect, sparse. *Female:* Ground color as in male, but with more extensive elytral black coloration, often enveloping entire elytra; antennae extending beyond mid-elytra. Length, 12-19 mm.

Holotype male, allotype female, and 17 paratypes (11 males, 6 females), "Boise City," Idaho (L. Brunner); 2 females labelled "Idaho" appear to fit into this group but are not designated as paratypes.

This subspecies is distinctive by its extensive elytral darkening and also differs in punctation. *C. coralinus ascendens* which is most similar in markings, may be readily differentiated by the less dense and less coarse punctures of the elytral base and less coarse pronotal punctures.

Crossidius rhodopus immaculipennis Chemsak and Linsley, new subspecies

Form and size of *rhodopus rhodopus* Linsley but pale brownish-testaceous in color. Legs and antennae reddish with distal antennal segments frequently rufo-piceous. Pronotum usually rufous, often partially piceous. Elytra concolorous with no indication of dark infuscation in either sex, each elytron with two visible costae. Length, 12.5-16 mm.

Holotype male, allotype female and 21 paratypes (16 males, 5 females), 10 miles north Smith, Lyon County, Nevada, August 12, 1958 on *Chrysothamnus nauseosus* (F. D. Parker).

This subspecies differs from the others now known by the pale ground color and absence of darkened areas on the elytra.

Crossidius rhodopus flavescens Chemsak and Linsley, new subspecies

Form and size of typical subspecies but ground color dark brown-yellow, with black appendages. Male with elytra often broadly clouded with black, however black area usually absent or reduced. Female usually with black clouded area about as extensive as in *C. rhodopus rhodopus*.

Holotype male, allotype female and 182 paratypes (11 females, 171 males), Kennedy Meadow, Tulare County, California, August 31, 1958 (A. Menke, L. Stange).

This subspecies occurs in the southeastern part of the Sequoia National Forest Area and differs from the others now known by the black appendages and the brown-yellow ground color.

Of the 172 male specimens available for study, 61 have the elytra immaculate, 89 have the dark cloud greatly reduced to a narrow sutural line, and 22 have an extensive clouded black area. Of the 12 females, two have immaculate elytra, one has greatly reduced, and nine have an extensive clouded black elytral spot.

Crossidius hirtipes nigripennis Chemsak and Linsley, new subspecies

Form and size of *hirtipes hirtipes* LeConte, but much darker in color. Dark pattern of elytra greatly expanded in both sexes, frequently covering the entire dorsum; basal band broad, extending back to well behind humeral angles; sutural stripe almost always confluent with basal band; pubescence pale, fairly dense but not obscuring punctation; female almost black above, with only extreme side margins of elytra testaceous.

This subspecies may be recognized by the extremely expanded dark elytral markings.

Holotype male, allotype female, and 79 paratypes (65 males, 14 females), Riggins, Idaho County, Idaho, August 18 and 26, 1958 on *Chrysothamnus viscidiflorus stenophyllus* (2 males, 1 female on *C. nauseosus typicus*) (W. F. Barr). This subspecies occurs in the Salmon River Valley area of western Idaho.

Crossidius hirtipes francesae, new subspecies

Form and size of typical *hirtipes hirtipes* LeConte but paler testaceous in ground color. Black markings of elytra reduced slightly in both sexes; basal black band of elytra greatly reduced, narrow, sutural stripe in male narrow, usually joining basal band behind scutellum, in female only slightly expanded, joining basal band, never covering most of elytra; pubescence moderately dense, long, not obscuring punctures of pronotum or elytra.

Holotype male, allotype female, and 73 paratypes (51 males, 22 females), Weed, Siskiyou County, California, August 23, 1958 on *Chrysothamnus viscidiflorus typicus* (F. Powell, J. A. Powell). Additional paratypes are as follows: 30 males, 7 females, 10 miles NE Weed, Siskiyou County, California, August 23, 1958 (F. Powell & J. A. Powell), on *C. viscidiflorus typicus*. (One female also taken on *C. nauseosus albicaulis*); 12 males, 11 females, 15 miles NE Weed on *C. viscidiflorus typicus* (one male and one female on *Haplopappus bloomeri angustatus*) (J. A. Powell). Additional material not designated as paratypes as follows: 15 males, two females, Antelope Creek, near Tennant, Siskiyou County, California, August 13, 1958 on *C. viscidiflorus typicus* (J. A. Powell); 8 males, 2 females, Antelope Creek, August 15, 1914, "on sage" (R. Hopping).

This subspecies occurs in the Shasta Valley of Northern California, and is named for Frances Powell, who assisted in the collection of the type series.

Crossidius hirtipes setosus Chemsak and Linsley, new subspecies

Form and size of typical *hirtipes hirtipes* LeConte but paler testaceous in ground color with reduced elytral black markings. Basal band of elytra narrow, seldom confluent with narrow sutural stripe; pubescence of pronotum long and dense, obscuring pronotal punctation; antennal scape with short dark bristle-like hairs interspersed with longer hairs.

This subspecies can be readily distinguished by the paler color, reduced elytral markings and by the presence of the bristle-like hairs of the antennal scape. It differs from *francesae* by the denser pubescence of the elytra and pronotum, less shining appearance, bristles of the scape and by the sutural stripe rarely joining the basal one.

Although the presence of the bristles on the scape would suggest an affinity with *C. punctatus*, *setosus* has been placed in the *hirtipes* group on the basis of other characters, such as the shining pronotal disk, punctation, and the general appearance based on the over all coloration.

Holotype male, allotype female, and 29 paratypes (24 males, 5 females), Boca Dam, 11 miles E. Truckee, Nevada County, California, September 1 and 11, 1957 on *Chrysothamnus viscidiflorus pumilis* (E. G. Linsley). Additional specimens are as follows: 8 males, 2 females from 4 miles N. Truckee, Nevada County, California, September 5, 1957, on *C. viscidiflorus typicus* (J. A. Chemsak, B. J. Adelson); two females from Truckee, August 31, 1955 (J. M. Linsley); 4 males, 2 females from 1 mile S. Hobart Mills, Nevada County, California, September 1, 1957 on *C. viscidiflorus typicus* (E. G. Linsley, J. M. Linsley); 7 males, 2 females from Prosser Creek

(North side), 2 miles S. Hobart Mills, August 23, 1956, on *C. viscidiflorus typicus* (E. G. Linsley).

Crossidius hirtipes immaculatus Chemsak and Linsley, new subspecies

Form and size of typical *hirtipes hirtipes* LeConte, but paler testaceous in color. Elytral markings greatly reduced, the males immaculate or with a very narrow sutural stripe, the females with sutural stripe reduced, narrow. Pubescence moderately dense, partially obscuring pronotal punctures, elytral hairs fairly long, abundant; hairs on antennal scape long, light and thin.

This subspecies differs by the immaculate elytra (or nearly so) of the male and the narrow sutural stripe in the female. It differs at once from *setosus* by the lack of bristle-like dark hairs on the antennal scape.

Holotype male, allotype female, and 187 paratypes (144 males, 43 females), Litchfield, Lassen County, California, September 7 and 8, 1957, on *Chrysothamnus viscidiflorus typicus* (E. G. Linsley, B. J. Adelson and J. A. Chemsak). Additional specimens not designated as paratypes are as follows: 14 males, 7 females, Johnstonville, Lassen County, California, on *C. viscidiflorus typicus* (E. G. Linsley, B. J. Adelson, and J. A. Chemsak); 1 male, 15 miles S. Ravendale, Lassen County, California, September 7, 1957, on *C. nauseous consimilis* (B. J. Adelson); 9 males, 2 females, 2 and 4 miles west of Standish, Lassen County, California, September 7 and 8, 1957, on *C. viscidiflorus typicus* (E. G. Linsley, B. J. Adelson & J. A. Chemsak); 1 male from 3 miles south of Janesville, Lassen County, California, September 8, 1957, on *C. nauseous speciosus* (E. G. Linsley); 23 males, 7 females, 3 and 7 miles NW of Milford, Lassen County, California, September 8, 1957, on *C. viscidiflorus typicus* (E. G. Linsley, B. J. Adelson & J. A. Chemsak); 6 males, 9 females from Hallelujah Junction, 2 miles south, 5 miles south, and 6 miles north, Lassen County, California, September 6 and 9, 1957, on *C. nauseous consimilis* (E. G. Linsley, B. J. Adelson & J. A. Chemsak) (1 female taken on *C. nauseosus speciosus*); 8 males, 3 females, 3 miles NW Sierraville, Sierra County, California, September 9, 1957, on *Chrysothamnus* (E. G. Linsley and J. M. Linsley); 1 male, 2 miles W. Loyalton, Sierra County, California, September 9, 1957 (E. G. Linsley); 148 males, 27 females, Reno, Sky Ranch, Washoe County, Nevada, September 10 and 15, 1945 (A. T. McClay); 37 males, 9 females, Reno, Nevada, September 11, 1945 (A. T. McClay); 84 males, 22 females, Pyramid Lake, Washoe County, Nevada, September 9 and 11, 1945 (A. T. McClay); 3 males, Pyramid Lake, August 20, 1957, on *Chrysothamnus* (J. W. MacSwain); 1 male, 1 female, Nixon, Washoe County, Nevada, September 13, 1957, on *C. viscidiflorus* (E. G. Linsley); 1 female from 2 miles N. Nixon, September 13, 1957, on *Gutierrezia sarothrae* (E. G. Linsley); 7 males, 1 female, Winnemuca, Humboldt County, Nevada, August 30, 1956 (T. R. Haig); 8 males, 3 females, Wadsworth, Washoe County, Nevada, September 11, 1945 (A. T. McClay); 22 males, 10 females, 8 miles N. Sparks, Washoe County, Nevada, August 20, 1951, on *Chrysothamnus* sp. (J. W. MacSwain); 47 males, 27 females, 1 mile south and 1 mile north of Carson City, Ormsby County, Nevada, September 9, 1957, on *C. viscidiflorus typicus* (J. A. Chemsak & B. J. Adelson); 1 male, 2 miles south Carson City, August 18, 1956, on *Haplopappus cooperi* (E. E. Lindquist); 3 males, 1 female from Eagle

Valley, 2.5 miles NW. Carson City, September 22, 1953 on, *C. viscidiflorus* (P. C. Ting); 15 males, 6 miles south of Washoe City, Washoe County, Nevada, September 9, 1957 on, *C. viscidiflorus typicus* (J. A. Chemsak & B. J. Adelson); 34 males, 3 females, September 6, 1958 (E. I. Schlinger), 2 males, 2 females, September 1, 1938 (W. E. Simonds), Coleville, Mono County, California.

This subspecies has a tendency to show a gradual variation in color and elytral pattern. This becomes evident from the numerous specimens from many localities within its range. The adequate series available show subtle changes in coloration between populations but the specimens from intermediate localities blend in with the extremes very well. South from Litchfield, there is a tendency toward more elytral black coloration down to Hallelujah Junction and west to Susanville. However, in Reno and Pyramid Lake a reduction of the sutural pattern occurs with the specimens exhibiting a somewhat darker testaceous color. Progressing south from Reno the color tends to be a little paler testaceous.

The chief host for the subspecies is *Chrysothamnus viscidiflorus typicus* but others are also utilized as listed above.

SOME POSSIBLE EFFECTS OF MALATHION AND EPN ON MICE[1]

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Mammals may be exposed to insecticides directly or through residues in food. During the last few years, organic phosphorus insecticides have found increasing usefulness and many mammalian studies are being conducted with these compounds.

One of the insecticides of interest, because of its wide use and low mammalian toxicity, is malathion. Holland *et al.* (1952) determined LD_{50}'s of different grades of purity and found the purer grades to be less toxic. They also found that rats tolerated satisfactorily 1000 p.p.m. malathion continuously in their diet. EPN is more toxic to mammals than malathion. Hodge *et al.* (1954), working with EPN, found that female rats were more susceptible than males to acute intoxication. They also found no histological changes in rats' organs as a result of chronic feeding.

A mixture of insecticides may have more than its expected additive toxicity (potentiation). Frawley *et al.* (1957), by blood cholinesterase de-

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pression, found potentiation between malathion and EPN in rats and dogs. They determined an LD_{50} combination in rats of about 165 mg. malathion plus 6.6 mg. EPN per gk. To confirm some phases of malathion-EPN potentiation, an LD_{50} for mice with this combination was determined in this study.

Lehman *et al.* (1955) mentioned that in addition to chronic feeding tests on mammals, reproductive studies should be conducted. It is believed that the added load of the stresses of growth, pregnancy, and lactation may increase susceptibility to the toxicity of a compound. This investigation included reproductive studies which were made on mice using malathion and, in one case, a malathion-EPN combination to determine if fertility or litter survival and growth would be adversely affected. Both an acute and a chronic study were conducted.

MATERIALS AND METHODS

The experimental animals were Swiss white mice. They were kept in a constant-temperature (25° to 27° C.) rearing room and were provided amply with Purina Laboratory Chow and water. The mice were identified by clipped toes.

The insecticides used were technical 95 per cent malathion[5] and crystalline EPN[6]. The EPN was recrystallized from technical EPN in a 1:1 mixture of isopropyl and methyl alcohols.

Average volume of the dosing solutions was about 0.1 ml. Solvent for the insecticides was corn oil. Dosages were calculated as mg. insecticide per kg. body weight.

The dosing was done with a ¼ cc. B-D Yale Tuberculin syringe and an 18-gauge, blunt curved needle. Before dosing, the mice were anesthetized with glass-distilled diethyl ether in a bottle containing the ether vapor. The mice were dosed orally by introducing the needle down the esophagus into the stomach and ejecting the calculated dose, based on its weight.

LD_{50}'s were determined by picking wide spread dosages over a range that would include 0 to 100 per cent mortality. Two mice were dosed at each dosage. Dosages were then selected between the points of 0 and 100 per cent mortality and several mice used at these levels. If the points covered the range from low to high mortality, more mice were added and these points used for the determination. The results were plotted on log-probit paper and LD_{50}'s calculated on an IBM 650.

An LD_{50} for malathion-EPN combination was determined, as were LD_{50}'s for compounds alone. The dosages were expressed as percentages of their individual LD_{50}'s. The ratio of the two compounds was kept the same. During dosing, two separate solutions were made and administered one immediately following the other.

Eight treated females, four control females, and two untreated males were used for each of the different dosage levels for the two reproductive

[5] O,O-dimethyl 5-(1,2-dicarboethoxy-ethyl) dithiophosphate, product of American Cyanamid Company.

[6] O-ethyl-O-p-nitrophenyl benzenethiophosphate, product of E. I. du Pont de Nemours and Company.

studies. Mice used in the acute toxicity study received one dose at the beginning of the experiment. The dosage levels were 2500 mg./kg. (LD_{50}), 1250 mg./kg. (½ LD_{50}), and 625 mg./kg. (¼ LD_{50}).

The chronic toxicity study had four dosage levels. One was 526 mg. malathion/kg. twice a week, Wednesdays and Saturdays; and 5 mg. EPN/kg. once a week, Monday. The other three dosage levels (526 mg./kg., 263 mg./kg., and 132 mg./kg. per dose) consisted of malathion alone, twice a week, Wednesdays and Saturdays, for 19 weeks.

In both studies the males were removed after 19 weeks and data collection terminated after 25 weeks.

When a mouse showed signs of pregnancy, it was transferred to a gallon jar with food and water. The number of young and weight of litter were recorded at least weekly. The young were weaned at three weeks of age at which time their mothers were returned to the cages with the males.

RESULTS AND DISCUSSION

The LD_{50}'s determined for 95% malathion were 2000 mg./kg. in male mice and 2500 mg./kg in females. The LD_{50}'s for crystalline EPN were 38 mg./kg. in males and 42 mg./kg. in females. In both cases the LD_{50}'s for the females were significantly higher than for the males at the 5 per cent level.

The LD_{50} in male mice, when a combination of malathion and EPN was administered, was about 13 per cent of the LD_{50}'s of each compound separately. This was 260 mg. of 95 per cent malathion per kg. plus 5.0 mg. crystalline EPN per kg. If one compound were expressed in terms of the other, the sum would be a sublethal dose, indicating some potentiation between these two compounds. These results are not much different from those determined by Frawley *et al.* (1957) on rats.

The results of the single-dose-treatment reproductive study are given in Tables 1, 2, and 5. Table 1 gives the size and weight of the litters and the survival ratios of the young. Litter size and litter weight were analyzed statistically. When the probability that the real value for the control was greater than 50 percent, it was considered to imply significance.

It was concluded that the one-dose treatment of malathion did not affect litter size and weight. It may have been responsible for some reduction in survival of the young between birth and weaning in the case of one of three treatments, but that is not indicated in the case of the highest dosage level.

The reproductive performance per mouse is given in Table 2. The numbers of young born and weaned per mouse were analyzed statistically. When the probability was greater than 50 per cent that the controls had the larger value, it was considered to imply significance.

In all of the values in Table 2, the controls had higher values than the treated. It was concluded that these acute, one-dose, malathion treatments probably were responsible for reducing the number of litters born and weaned per mouse and the number of young born and weaned per mouse.

TABLE 1. Average size and weight in grams of litters and survival ratios of young from mice receiving one dose of malathion.

Dose[1]	1(a)	1(b) control	2(a)	2(b) control	3(a)	3(b) control
Average rank no.	II		III		I	
young born per litter	8.50	8.78	8.44*	9.67	8.60	7.29
Average rank no.	I		II		III	
young weaned per litter	8.31	7.67	8.17	8.40	7.75	7.29
Average litter	I		III		II	
weights at birth	13.39	13.55	11.82*	14.35	12.40	11.06
Average litter	I		II		III	
weights at weaning	74.56	66.18	65.03	68.04	61.70	60.74
Ratio no. young	I		III		II	
weaned to no. young born	.908	.885	.645	.724	.721	1.000

* Control value larger at 50 per cent of probability.
[1] 1(a)—8 female mice receiving a dose of 2500 mg. malathion/kg. in corn oil.
1(b)—4 female mice, controls for 1(a), receiving control dose of corn oil.
2(a)—8 female mice receiving a dose of 1250 mg. malathion/kg. in corn oil.
2(b)—4 female mice, controls for 2(a), receiving control dose of corn oil.
3(a)—8 female mice receiving a dose of 625 mg. malathion/kg. in corn oil.
3(b)—4 female mice, controls for 3(a), receiving control dose of corn oil.
Ranks: would expect 1 to have lowest figures, 2 to be between, and 3 to have highest figures among treated. In no case did the highest dosage level result in lowest figure.

TABLE 2. Average reproduction per female white mouse treated with one dose of malathion.

Dose[1]	1(a)	1(b) control	2(a)	2(b) control	3(a)	3(b) control
Average no. litters born per mouse	1.75	2.25	1.13	1.50	1.25	1.75
Average no. litters weaned per mouse	1.63	2.25	0.75	1.25	1.00	1.75
Average no. young born per mouse	14.88	19.50*	9.50	14.50*	10.75	12.75
Average no. young weaned per mouse	13.50	17.25*	6.13	10.50*	7.75	12.75*

* Control value larger at 50 per cent of probability.
[1] For dosage details see footnote of Table 1.

The results of the chronic treatment reproductive study are given in Tables 3, 4 and 5. Table 3 gives the size and weight of the litters and the survival ratios of the young. The litter size and litter weight were analyzed statistically. As in the one-dose treatment, when the probability that the real value for the control was greater than 50 per cent, it was considered to imply significance.

It was concluded that the chronic treatments of malathion alone, did not decrease litter size or weight or survival of the young. When EPN was added, a possible reduction in size and weight of litter and survival of young was indicated.

The reproduction per mouse is given in Table 4. The number of young born and weaned per mouse was analyzed statistically. As in the one-dose treatment, when the probability was greater than 50 per cent that the controls really had the larger value, it was considered to imply significance.

TABLE 3. Average size and weight of litters (in grams) and survival ratios of young from chronically-treated female mice.

Dose[1]	1(a)	1(b) control	2(a)	2(b) control	3(a)	3(b) control	4(a)	4(b) control
Average no. young born per litter	5.78*	8.75	8.75	8.50	7.78	7.60	7.71	8.11
Average no. young weaned per litter	6.00*	8.25	7.15	6.14	7.14	6.20	7.20	7.29
Average litter weights at birth	10.07	12.93	12.97	11.40	12.24	11.50	10.80	12.28
Average litter weights at weaning	57.47*	70.92	59.32	48.98	70.64	57.70	67.58	62.81
Ratio no. young weaned to no. young born	.692	.943	.664	.632	.714	.816	.667	.699

* Control value larger at 50 per cent of probability.
[1] 1(a)—8 female mice receiving malathion (526 m./kg./dose) twice a week plus 5 mg./kg. EPN once a week on different day.
1(b)—4 female mice, controls for 1(a), receiving 3 control doses of corn oil per week.
2(a)—8 female mice receiving malathion (526 m./kg./dose) twice a week.
2(b)—4 female mice, controls for 2(a), receiving 2 control doses of corn oil per week.
3(a)—8 female mice receiving malathion (263 m./kg./dose) twice a week.
3(b)—4 female mice, controls for 3(a), receiving 2 control doses of corn oil per week.
4(a)—8 female mice receiving malathion (132 mg./kg./dose) twice a week.
4(b)—4 female mice, controls for 4(a), receiving 2 control doses of corn oil per week.

TABLE 4. Average reproduction per chronically-treated female mouse.

Dose[1]	1(a)	1(b) control	2(a)	2(b) control	3(a)	3(b) control	4(a)	4(b) control
Average no. litters born per mouse	1.13	1.00	2.00	2.00	1.13	1.25	1.75	2.25
Average no. litters weaned per mouse	0.75	1.00	1.63	1.75	0.88	1.25	1.25	1.75
Average no. young born per mouse	6.50	8.75	17.50	17.00	8.75	9.50	13.50*	18.25
Average no. young weaned per mouse	4.50*	8.25	11.63	10.75	6.25	7.75	9.00*	12.75

* Control value larger at 50 per cent of probability.
[1] For dosage details see Table 3.

In both the acute and chronic treatments, the number of mice used was too small to detect a significant difference in all cases. A general comparison was, therefore, made of both studies with the data in Tables 2 and 4. The value of the treated was divided into the value of the control. A value of less than one would imply that the treatment was beneficial and a value greater than one would imply that the treatment was harmful. These data are given in Table 5.

TABLE 5. Reproductive comparison per mouse expressed as the ratio of the control to the treated.

Dose[1]	A	B	C	D	E	F	G
Litters born	1.29	1.33	1.40	0.88	1.00	1.11	1.29
Litters weaned	1.38	1.67	1.75	1.33	1.07	1.42	1.40
Young born	1.31	1.53	1.19	1.35	0.97	1.09	1.35
Young weaned	1.28	1.71	1.65	1.83	0.92	1.24	1.42

[1] A—Acute 2500 mg./kg. malathion.
B—Acute 1250 mg./kg. malathion.
C—Acute 625 mg./kg. malathion.
D—Chronic 2 doses weekly of 526 mg./kg. malathion and one dose weekly of 5 mg./kg. EPN.
E—Chronic 2 doses weekly of 526 mg./kg. malathion.
F—Chronic 2 doses weekly of 263 mg./kg. malathion.
G—Chronic 2 doses weekly of 132 mg./kg. malathion.

In all but three cases the value is greater than one. This consistently greater-than-one value for the one-dose treatment (A, B, C) tends to support the conclusion that these acute treatments decreased productivity. The slightly greater-than-one figure in most cases with chronic treatments implies that the treatment may have reduced productivity.

Summary.—Oral LD_{50}'s of malathion and EPN, and studies with reproduction, indicated some potentiation between these two compounds in mice. Acute one-dose malathion treatments did not affect litter size and weight; some slight reduction of survival of young was noted. Reduction of the total number of litters and young born and successfully raised was indicated, but this reduction was too slight to be conclusive.

From a chronic reproductive study it was found that it was not possible statistically to detect slight differences between treatments and controls. While in many instances the average results suggested reduced productivity, this was not significant statistically. The data do not conclusively indicate adverse effects but rather suggest the need for further investigations to establish the non-detrimental levels of combinations of malathion and EPN.

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THE EFFECT OF VARIOUS HUMIDITY LEVELS ON HATCHABILITY OF PINK BOLLWORM EGGS[1]

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The pink bollworm, *Pectinophora gossypiella* (Saund.), has spread across a large part of the Cotton Belt. In 1958, pink bollworms were found in Arkansas near the Mississippi River in areas not known to be previously infested. Infestations were also discovered in Arizona, in an area from which the insect had once been eradicated. This spread of the insect into areas having diverse climatic conditions is of special interest to persons concerned with the ecology of the pink bollworm.

Of the many ecological factors studied, the effect of relative humidity on the biology of the insect has been of particular importance to certain investigators. Fenton and Owen (1953) published data indicating that humidity had an important influence on longevity of pink bollworm moths. They found that the moths live for much longer periods of time at approximately 80% relative humidity than at approximately 40%. Lukefahr and Griffin (1957) reported that there appeared to be little difference in the rate of oviposition occurring at relative humidities of 50%, 85% and 90%, respectively, when the temperature was held constant at 85° F.

However, Showers (1958) failed in his efforts to obtain high levels of pink bollworm infestations in irrigated cotton grown under large field cages. He theorized that the high relative humidities present under the experimental conditions of the study may have been partly responsible for this failure.

Since previous work by Lukefahr and Griffin (1957) had indicated that humidity has little influence on rate of oviposition, this investigation was conducted to study the influence of relative humidity on hatchability of pink bollworm eggs.

Procedure.—The humidity chambers consisted of glass battery jars 6 inches in diameter by 18 inches in height and having a capacity of approximately 1½ gallons. The tops of the jars were smeared with petroleum jelly and sealed with plate glass covers. A lantern globe was placed inside each jar. A screen cut from heavy gauge hardware cloth and of a slightly smaller diameter than the jar was placed on top of the lantern globe. This arrangement proved suitable for holding the egg containers in the upper portions of the jars.

Relative humidities were obtained by using methods as outlined in the "Handbook of Chemistry and Physics" (36th Ed., Chemical Rubber Publishing Co., Cleveland, Ohio, 1954) as follows: 0% level maintained by calcium chloride, 45% and 75% by H_2SO_4 solutions, and 100% or saturated by distilled water. Humidities were verified periodically by a hy-

[1] Technical Contribution No. 3278 Texas Agricultural Experiment Station in cooperation with Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture.

grometer and adjustments made as necessary. The humidity chambers were held in a constant temperature room at 80° F.±2°.

One-day-old pink bollworm eggs were used for all tests. The eggs were collected daily from cotton leaves taken from oviposition cages maintained at this laboratory. Eggs were transferred from the leaves to pieces of filter paper cut to fit the bottoms of petri dishes. The transfer was accomplished with a moistened camel hair brush. Fifty eggs were placed in each dish and one dish was placed in each humidity chamber. This was considered to be one replication. Five replications of each treatment were made over a 6-week period.

The petri dishes (without tops) were placed on the lantern globe racks. The jars were then sealed. At the end of 7 days the dishes were removed and the eggs were examined under a binocular microscope and the numbers of hatched and unhatched eggs recorded. Preliminary tests indicated that a 7-day test period would furnish a reliable indication of the effect of humidity on hatchability of eggs under the experimental conditions described.

The percentages of eggs to hatch in each replication were transformed to angles according to the methods of Snedecor (1956) and subjected to the analysis of variance.

Results and Discussion.—Results are presented in Table 1. The greatest percentages of eggs hatched at the higher humidity levels of 75% and 100% relative humidity. The numbers of eggs that hatched at these levels were significantly greater at the 1% level of probability than the numbers that hatched at the two lower levels. However, approximately 50% of the eggs exposed to the lower humidities hatched. This would indicate that humidities normally occurring in the field probably would not greatly retard pink bollworm infestations. Thus, these results along with previous work by Lukefahr and Griffin (1957) suggest that the failure of Showers (1958) to obtain severe pink bollworm infestations were due to factors other than humidity.

TABLE 1. Percentage of pink bollworm eggs hatched when held at different humidities for 7 days.

Relative Humidity	Average Percentage Hatch
0	67.5
45	58.3
75	90.4**
Saturated	88.0**

** Statistically higher percentage hatch at the 1% level of probability than recorded for the two lower levels.

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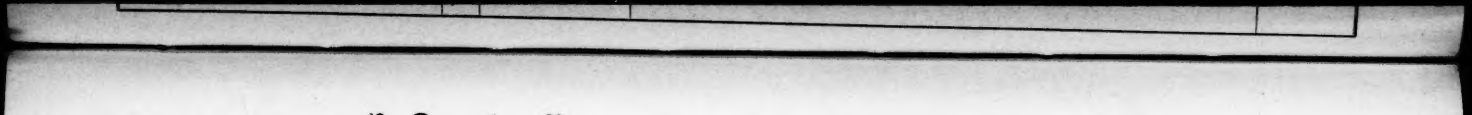
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